Under the Influence of Connectives:

How Connective Location and Clause Order Interact in Online Processing and Retention of Text

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I investigated the effect of cohesiveness on reading strategies and retention of causal relationships and details within a text. Participants read brief expository texts while their eye movements were tracked. I manipulated the cohesiveness of each text by varying the location or presence of a causal connectives (e.g., *because, so*) within a sentence and the order in which the clauses were presented (forward versus backward causal structure). Prior literature has found cohesive text can contribute to declines in elaborative processing and lead to lower retention; however, I found the opposite pattern: Causal relationships and text details were more likely to be remembered as cohesion increased. Further, the online reading results converged to suggest (a) when a connective is present at the beginning of a sentence, readers will employ strategies to put off processing of an effect clause until they access the causal information, (b) readers pay particular attention to causes, suggesting integration of causal relationships requires more attention to the cause than to the effect, and (c) readers do not differentiate between forward and backward causal structures when a connective is absent. Altogether, I did not find evidence that reading strategies related to elaboration and integration diminished when a connective was present. Instead, I found only that reading times increased when a connective was absent. The increased reading times when a connective was absent may reflect more extensive elaboration, but elaboration is not absent when a connective is present, only constrained. The results support a view in which connectives influence reading strategies and facilitate a correct and sustained understanding of text.

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Preface

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1.0 Introduction

During reading, successful comprehension involves constructing a mental representation or *situation model* of the text (van Dijk & Kintsch, 1983). A critical process in formation of the situation model is the integration of sentences with surrounding text and prior knowledge. The integrated representation is more likely to be retained than the individual components of the text (van Dijk & Kintsch, 1983). For example, Black and Bern (1981) found that when readers read causally related sentences, as in (1a), they often later recalled the separate sentences as a unit, as in (1b) (Black & Bern, 1981). They suggested that readers integrated the sentences by using their prior knowledge to identify a causal relationship between the two clauses and formed a single concept from the text.

(1a)The child was pulling at a bottle. It fell to the floor and broke.

(1b)The child broke the bottle.

A critical question is what devices contribute to a successful situation model? In this study, I considered whether the presence of specific cohesive devices (i.e., causal connectives and cause-effect structures) facilitate the integration of clauses. I contrast a view in which excessive cohesion can harm comprehension by limiting the need for elaborative processing during reading with a view in which connectives constrain inferencing leading to more accurate processing. Further, to understand how different cohesive devices might differentially affect reading strategies, I used eye tracking to measure the reading times and regression probabilities at key points in the text.

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1.1 What makes for an effective text?

Connectives (e.g., *because, so*) are a commonly used text device that make relationships among clauses explicit. But as the above example by Black and Bern (1981) illustrated, readers can trigger integrative processes even in the absence of connectives, especially when the structure of the text is causal. In the absence of connectives or other cohesive devices (e.g., causal verbs), readers attempt to integrate adjacent clauses causally by default, as evidenced by the difficulty readers have with processing clauses that are not causally related (Khoo, Chan, & Niu, 2002). In the absence of connectives, as the causal relatedness between two sentences becomes more distant, reading times for the second sentence increase (Keenan, Baillet, & Brown, 1984) and when a causal relationship is absent, recall decreases (Black & Bern, 1981; Trabasso & van den Broek, 1985). However, although having some causal relationship between sentences improved recall, too much causal relatedness (Keenan et al., 1984; Myers, Shinjo, & Duffy, 1987; Duffy, Shinjo, & Myers, 1990) and cohesiveness[1] (Irwin, 1980; Millis, Graesser, & Haberlandt, 1993) had an inverse effect on recall—though some studies have shown this is only true for readers with high

[1] Cohesion is defined differently across subject fields (e.g., Carrel, 1982). Here I define cohesion as the extent to which the relationship among the clauses is made explicit (Ozuru, Dempsey, & McNamara, 2008). This can take several forms and be measured, in part, as the extent to which anaphors, causal verbs, elaborative text, and connectives are used in a passage (Graesser, McNamara, Louwerse, & Cai, 2004).

domain knowledge (Duff, Kohut, & Norberg, in prep; McNamara et al., 1996) or when using simple texts (Linderholm et al., 2000), and others that it is further limited to less skilled readers with high domain knowledge (O'Reilly & McNamara, 2007; Ozuru et al., 2008; Voss & Silfies, 1996). The pattern of comprehension decreasing as cohesion increases has been dubbed the reverse cohesion effect (McNamara et al., 1997; O'Reilly & McNamara, 2007).

A clear question in light of the reverse cohesion effect is: If cohesion can be disadvantageous, then why are cohesive devices such as connectives so ubiquitous? The answer may come from the elaboration hypothesis (Myers et al., 1987). Elaboration is defined here as additional thoughts generated by the reader that are not explicitly stated in the text. Myers et al. (1987) suggested that when readers successfully use elaboration as a reading strategy, the elaboration is stored with the representation of the text and can facilitate later recall. The pattern they suggested is one of an inverse U (∩). On one end of the ∩, elaboration is not helpful for recall if comprehension has failed. On the other end, if comprehension occurred without elaboration, recall of the text is also harmed. Only when elaboration occurs and the relationships among the ideas in the text are comprehended is recall facilitated. As I will outline in greater detail below, the elaboration hypothesis predicts the reverse cohesion effect (Millis et al., 1993). In short, lower cohesion facilitates elaboration provided that the reader can comprehend the text.

The answer under the elaboration hypothesis to the question concerning why connectives are so ubiquitous is that connectives are necessary in circumstances when the reader is in danger of failing to comprehend. The elaboration hypothesis predicts that recall will suffer both if causal relatedness is too high and if it is too low (Myers et al., 1987). If a causal connective is being used correctly, causal relatedness between the two clauses is likely to be high, but this does not necessarily mean that the relatedness is easily detectable by the reader. Murray (1997) proposed

the continuity principle: readers will benefit from connectives most when continuity has been broken. This can happen through presenting contrasting material or by presenting clauses in an effect-cause structure (Maury & Teisserenc, 2005; Murray, 1997). When clauses are presented in an effect-cause structure, the events of the text have been presented backwards from temporal order. Prior literature has demonstrated that readers expect cause-effect (forward causal) structures; if they receive an effect-cause (backward causal) structure they may not be able to correctly process the relationship between the clauses and comprehension will suffer (Black & Bern, 1981; Irwin, 1980; Kaiser, 2019; Murray, 1997; Trabasso & van den Broek, 1985). A backwards causal structure may make the causal relationship too difficult to process without the aid of a connective. Indeed, the conditions in English in which causal connectives are most frequently used are when the continuity principle is violated by a backward causal structure. Based on the Corpus of Contemporary American English (COCA) the frequency of *because* when used in the middle of the sentence (i.e., a backward causal structure) is higher than the frequency of the connective version of *so* (i.e., a forward causal structure).[2] The higher usage of a connective in backward causal structures may reflect the greater propensity for a break down in comprehension under such constructions (Irwin, 1980; Linderholm et al., 2000; Murray, 1997).

Another possible answer to why connectives are ubiquitous is that they facilitate comprehension in all circumstances. Such a finding would be in contrast to prior work looking at

[2] Using COCA, I found that *so* when used as a connective had a raw frequency of 201,305 and because had a raw frequency of 476,691. Further, I identified when *because* occurred at the beginning of a sentence by checking to see if it followed any of the following words or characters: ".", "?", "and", "but", "so", ";". From this I estimate that *Because* introduces a cause-effect order with a raw frequency of 85,649 and *because* occurs in the middle of an effect-cause order with a raw frequency of 391,042.

cohesion more broadly (Linderholm et al., 2000; McNamara et al., 1996; O'Reilly & McNamara, 2007; Ozuru et al., 2008; Voss & Silfies, 1996) but consistent with some work specifically manipulating causal connectives (van Silfhout et al., 2015; Maury & Teisserenc, 2005; Millis & Just, 1994; Millis, Golding, & Barker, 1995, cf. Millis et al., 1993). It could be that effects found in prior studies do not apply to connectives. Connectives may be a special class of cohesive device due to their ability to provide processing instructions to the reader. Such instructions may mean that readers are encouraged to continue with elaborative processing during construction of the situation model and the resulting interpretation of the text. I use two devices related to cohesion in this study. One is the clause order. Forward causal structures are more cohesive than backwards structures (Linderholm et al., 2000). The other is causal connective presence.

A further possibility is that the reverse cohesion effect is only true in the short term. In fact, there is reason to believe that the memory trace of a less cohesive text may be more subject to interference and therefore decay at a faster rate than that of a more cohesive text. When reading causally related sentences, the absence of a connective may require greater elaboration in order for integration of the clauses to succeed. However, more elaboration may lead to multiple interpretations of the text. Previous work has shown that when readers activate multiple interpretations of a text, those interpretations can interfere with one another (Christianson, Hollingworth, Halliewell, & Ferreira, 2001; Paston, Darowski, Moon, & Ferreira, 2009). The extensive elaboration found when texts are less cohesive may initially lead to richer representations that facilitate recall when responding to bridging comprehension questions. But, over time, the elaborations retained in the situation model may decay and interfere with one another, leading to a break down in retention of the text. In this case, I would expect a greater decline in retention of the text in conditions which required greater elaboration in order for comprehension to succeed

(i.e., backward causal structures and clauses without connectives). On the other hand, a text with high levels of cohesion would constrain elaborations to those which fit with the relationship made explicit by the text. The signal would be less prone to interference from associated nodes developed during the formation of the situation model and memory would be stronger. The connective in this case is protective against alternative interpretations of the text over time.

We can further investigate the question of how cohesion affects text integration by looking at online processing. Most of the prior literature, when it has looked at online processing related to cohesion and connective use in particular, has used a moving window paradigm in which each word is shown one at a time (Cain & Nash, 2011; Keenan et al., 1984; Millis & Just, 1994; Maury & Teisserenc, 2005; Zufferey & Gygax, 2016). This allows for measures of reading times but does not allow for rereading. Measures of rereading could further the understanding of how connectives affect processing. Regressions made during reading may reflect integrative processes that provide additional information beyond reading times about when integration between the clauses is occurring and what prompts these processes (van Silfhout, Evers-Vermeul, & Sanders, 2015). I used free reading with eye-tracking to allow the reader to process material at their own pace and reread as necessary. I focused our analysis on eye-tracking measures believed to reflect processing difficulty and integration; i.e., first pass time, total time, go past time (i.e., regression duration), and the binary variable of regressions out (Just & Carpenter, 1980; Millis & Just, 1994; Rayner, Chace, Slattery, & Ashby, 2006). The memory measures targeted both the retention of the relationships among clauses in the text and details within those the clauses.

1.2 What processing instructions do connectives provide

The placement of a connective between clauses has consistently resulted in faster reading times (Cain & Nash, 2011; Haberlandt, 1982; Maury & Teisserenc, 2005; Millis & Just, 1994; van Silfhout et al., 2015; Zufferey & Gygax, 2016), typically thought to be reflective of easier processing (Rayner, 1998; Rayner et al., 2006). Connectives may make processing easier and more passive by making explicit the relationships among clauses and decreasing the need for readers to fill in gaps in the text with inferences based on their prior knowledge (McNamara et al., 1996; O'Reilly & McNamara, 2007; Ozuru et al., 2008). If connectives promote a more passive reading process, reading times following a connective may be consistently faster without showing signs of strategic processing. However, when van Silfhout et al. (2015) used eye-tracking measures, they found an increased probability of regressions out of the region following the connective. The measure of regressions out has often been discussed as an indication of processing difficulty (Ferreira & Henderson, 1993; Rayner et al., 2006), but overall go past times in the van Silfhout et al. study—measured as total time before moving to the right of the region—were shorter in connective present conditions suggesting that the increased regressions were not due to difficulty in processing. On the contrary, van Silfhout et al. suggested they were due to integrative processes driven by explicit cueing from the connective. This is not to say that integration was not present when connectives were absent. Consistent with the elaboration hypothesis, the longer go past times in no connective conditions found by van Silfhout et al. may reflect greater elaboration as the reader attempts to find a way to integrate the sentences. But the need for longer go past times may simultaneously reflect less certainty about how clauses within a passage should be integrated.

To better understand the role connectives play in active reading, I used eye-tracking measures to determine if the presence of causal connectives (a) reduced reading strategies and eased processing (i.e., resulted in faster reading times all around without increasing regressions) or (b) changed the readers' strategies based on the nature of the processing instructions. To test this, I varied the location of a causal connective (beginning or middle of the sentence) and the causal order (forward or backward) within a series of expository texts. The first finding would indicate that the faster reading times when a connective is present represent diminished active reading as processing become easier. The second finding would indicate that active reading remains following a connective, but the instructions provided by the connective about the relationship among the clauses lead to more targeted integration strategies, and it is the use of targeted active reading that results in the faster reading times.

If readers engage in more targeted reading following a connective, then the reading strategies should be specific to the conditions of the sentence. Reading patterns were similar across connective conditions in the van Silfhout et al. (2015) study, but they collapsed their results based on clause ordering (i.e., whether the clauses are in an iconic order) which may reduce sensitivity to differences among the connectives. If connectives act to change active reading strategies, a key opportunity for detecting that effect is when the order of the clauses switches from a forward causal relationship to a backward one. Since forward causal relationships have been shown to be a default processing order in text (Black & Bern, 1981; Keenan et al., 1984; Zwaan et al., 1995, Kaiser, 2019), readers may need to use more strategic process to successfully integrate clauses in a backwards causal structure and the presence of a connective may cue the reader as to which processes are best suited to the structure of the sentence. However, the extent and nature of the strategies should also depend on the location of the connective.

Nearly all of the studies conducted using online sentence processing have placed the connective between clauses. In fact, the only study I am aware of which manipulates the location of a connection is that conducted by Irwin (1980), and it did not include measures of reading time.[3] If connectives drive differences in reading strategies, then the location of the connective should change the strategy. For example, when a connective occurs at the beginning of the clause, readers may use this as a cue that what will follow is relevant only in relation to the second clause. This may result in increased reading speeds through the first clause, but critically produce reading patterns in the second clause that are suggestive of delayed processing of the first clause, including longer reading times and greater probabilities of regressing out of the second clause.

One consideration with these predictions is where within the sentence to look for differences. Some studies have proposed that integration is delayed until the end of the sentence (Millis & Just, 1994). However, as several studies have shown that readers attempt to integrate clauses incrementally (Traxler, Bybee, & Pickering, 2000; van Silfhout et al., 2015), effects of the connective may have diminished by the time the end of the second clause is reached. van Silfhout et al. (2015) and Canestrelli, Mak, and Sanders (2013) found effects immediately following the connective. I followed this approach and look for effects in the regions directly following a connective. However, as claims about the effects of connectives on reading strategies will be more robust if they include multiple parts of the sentence, I also looked at additional regions within the sentence and at the sentence as a whole to determine if they show the same patterns.

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[3] As a side note, the paucity of literature concerning the location of a connective within a sentence may be a large omission in the literature. For one, many findings concerning clause order may change if processing instructions are provided at the outset. For example, disruption from not beginning a sentence with a main clause (Jarvella & Herman, 1972) made diminish if the reader knows from the outset that the first clause is subordinate.

1.3 Retaining bridging inferences and text integrations

Theories that readers engage in more passive reading when connectives are present stem from a series of findings showing that, in certain circumstances, connectives can lead to diminished comprehension. One example of this included considerations of domain knowledge. McNamara et al. (1996) found that, when readers had high levels of domain knowledge on a topic, connectives and other coherence enhancing changes to a text (e.g., anaphors, causal verbs, and titles) inhibited later memory for *bridging inferences* about the relationship between clauses. Since the connective makes the relationship explicit, it drastically reduces the need for inference. McNamara et al. suggested that, when readers do not need to infer the relationship among clauses they are at risk of creating a superficial structure of the text that is less likely to be retained. The risk is heightened when the reader has high domain knowledge. When the text is difficult to process (i.e., less cohesive), readers with high domain knowledge can activate their prior knowledge to find the relationships among the clauses and create bridging inferences. However, when the text is particularly easy to process (i.e., cohesive), readers with high domain knowledge can skip this activation of prior knowledge and integrate the clauses passively. They benefit then from reading a less cohesive text that requires them to use their knowledge to determine how the various sentences are meant to relate. On the other hand, readers with low domain knowledge do not have the means to infer the relationship among the clauses, and so without an explicit processing cue, comprehension fails.

Subsequent work further found that this interaction between domain knowledge and cohesion occurs primarily for less-skilled readers with high domain knowledge (O'Reilly & McNamara, 2007; Voss & Silfies, 1996). Skilled readers with high domain knowledge performed equally well on bridging inference questions after reading more- and less- cohesive texts. These

studies suggest that part of what makes skilled readers skilled is that they are able to continue to read actively even when basic comprehension does not require it.

The diminished comprehension from highly cohesive texts among high domain knowledge readers, and particularly those who are less skilled, aligns with the elaboration hypothesis (Myers et al., 1987) that as elaboration increases, so will performance, provided that basic comprehension is accomplished. Figure 1 demonstrates how the findings of O'Reilly & McNamara (2007) can be mapped onto the elaboration hypothesis: Performance on bridging questions is lowest when elaborations have the least chance of occurring or when comprehension is the least likely to succeed; i.e., when readers have low domain knowledge and the text is not cohesive, comprehension is likely to fail, and when domain knowledge and cohesion are high but reading skill is lower, elaboration is less likely to occur even though comprehension might succeed. Finally, performance is highest in situations when elaboration is expected to be highest; i.e., when readers are skilled or when the less skilled readers with high domain knowledge read less cohesive texts which require them to elaborate based on their prior knowledge in order to successfully comprehend the text.

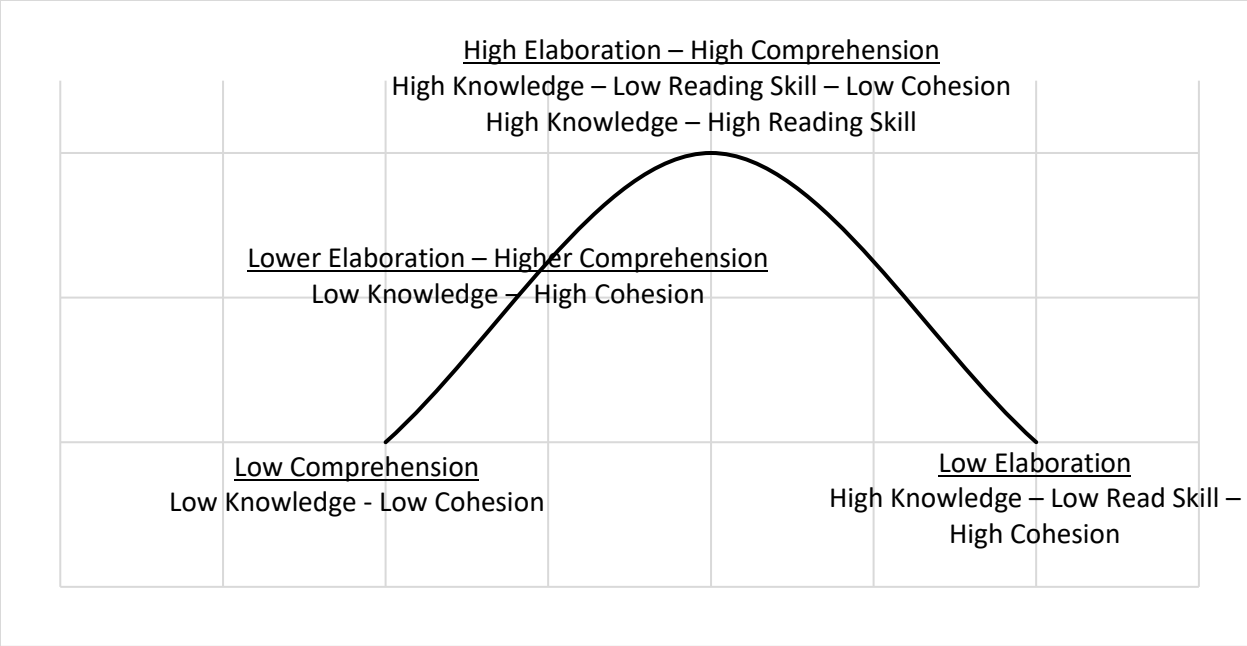

Figure 1 Performance curve mapping the interaction of domain knowledge, reading skill, and text cohesion onto the elaboration hypothesis.

Another example of the elaboration hypothesis can be found in manipulations of text difficulty. Linderholm et al. (2000) found that cohesion facilitated retention of the causal chain of events in a difficult text, but retention diminished among skilled readers for the easier text. The study demonstrates that, consistent with the predictions of the elaboration hypothesis, the reverse-cohesion effect is not limited to interactions between reading skill and domain knowledge.

In the present study, we examine the effect of connectives. Although the effect of connectives on retention of text may be similar to that of other cohesive manipulations, the literature presented above does not provide enough evidence to make this determination. Indeed, several of these studies make little use of connectives, especially causal connectives, in their cohesion manipulations, and most that do include causal connectives use them to bind sentences already in a forward causal structure (Linerholm et al., 2000; McNamara et al., 1996; O'Reilly & McNamara, 2007). As I remarked previously, causal connectives may be protective only in the

case of backwards causal structure, so the fact that the majority of studies use causal connectives in a forward causal structure could limit the ability of researchers to understand when cohesion is effective. Some evidence already suggests this to be the case. Studies carried out specifically on the effect of connective presence have used backwards causal structure, and in these cases, retention of the text has improved (Caron et al., 1988; Maury & Teisserenc, 2005; Millis & Just, 1994). Further, in a study where the materials were presented in both orders with either *so* or *because* in the middle, Murray & Teisserenc (2005) found that only backwards causal structure facilitated retention of the text.

The contrasting results between cohesion studies on the one hand, which pair causal connectives with forward causal structures, and connective studies on the other, which pair causal connectives with backward causal structure, may also be explained by the elaboration hypothesis. Murray (1997) proposed that discontinuity between sentences lowers coherence such that comprehension does benefit from connectives. According to his continuity hypothesis, connectives will improve processing and memory for text only when the text is discontinuous. For example, when *because* is placed between clauses, it will improve processing because it makes the temporally discontinuous order of events (effect-cause) easier to process. The implication is that if *so* is used to join two clauses or if *because* occurs at the start of the sentence, the presence of the connective will have little impact on processing because the forward causal structure does not violate continuity. As mentioned above, Murray & Teisserenc (2005) found little difference based on connective presence for forward causal structures but did find facilitation from backward causal structures joined by a connective. Specifically, they found that in science texts, clauses joined by *because* produced better memory for inferences than clauses joined by *so* and than clauses without a connective. It is possible then that textual continuity is a driving factor in determining text

coherence and difficulty and ultimately, whether discourse markers are beneficial. Irwin (1980) also found results which support this prediction. Participants read sentences which contained a reversible causal relationship (i.e., the sentence made sense with either clause as the cause or the effect). Again, comprehension reflected an advantage for connectives placed within backwards causal relationships. Further, Irwin found a disadvantage when connectives were included in forward causal structures as compared to the same structure without a connective.

The general theoretical claim driving this study was that the continuity principle provides additional evidence to support the elaboration hypothesis. Specifically, I expected that the interaction between two cohesive elements would moderate the reverse cohesion effect and produce the inverse U predicted by the elaboration hypothesis. To test this, I manipulated the order of presentation for a causal relationship to be either forward or backward. Not only is the forward relationship more cohesive (Linderholm et al., 2000), it is also easier to process (Kaiser, 2019; Keenan et al., 1984). Further, I varied the presence of connective to create more and less cohesive texts (Graesser et al., 2004) and the location of the connective on an exploratory basis. Under the elaboration hypothesis, I would expect that as cohesive elements increase, performance on questions concerning bridging relationships in the text will initially increase as some cohesion makes elaboration to fill in the remaining gaps possible but then ultimately decline at text processing becomes so easy that no elaboration is necessary. Figure 2 demonstrates this expectated effect. Either having a backwards causal relationship with a connective or a forward causal relationship without a connective will produce the ideal environment to stimulate elaboration and comprehension. When text cohesion gets too high in the case of a forward causal relationship with a connective present, elaboration will be less necessary, and retention of the text will decline.

Further, if the text has a backwards causal relationship and no connective, processing will be too difficult, and comprehension will fail.

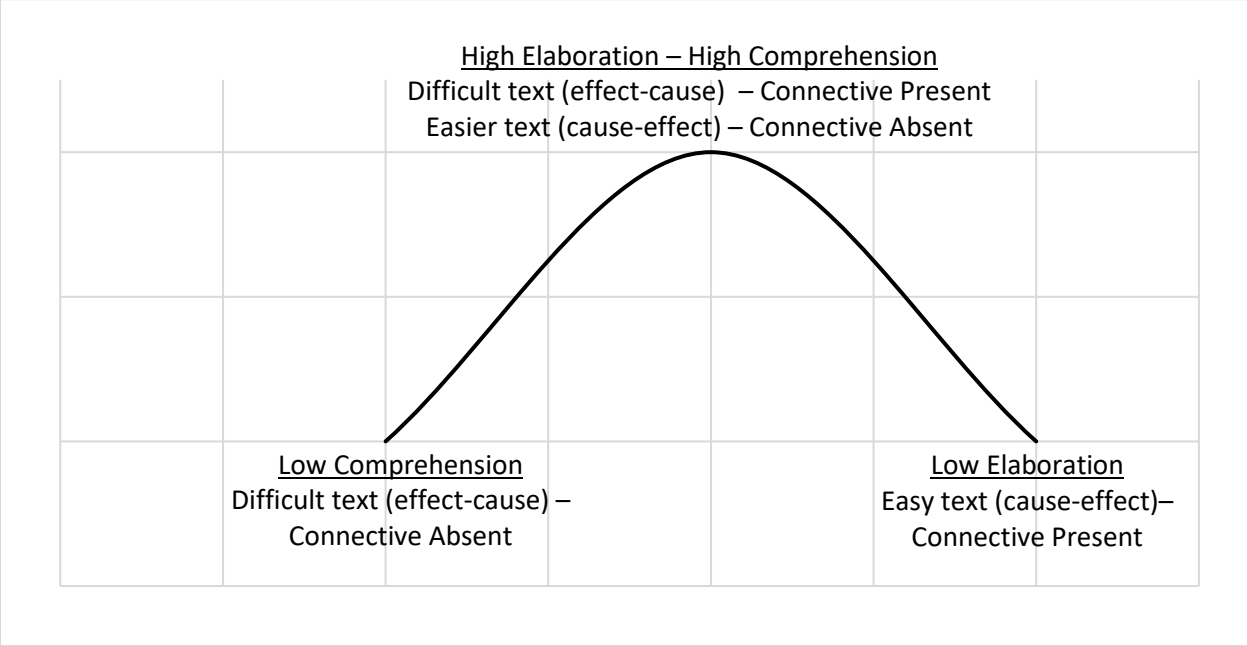

Figure 2 Performance curve 2 mapping the interaction of clause order and connective presence onto the elaboration hypothesis.

A competing view is that connectives may improve inferences, regardless of the overall level of cohesion, because they constrain interpretation. Haberlandt (1982) suggested that integration involves a search for clues—including connectives—as to how the writer intended the clauses to be related. Within the context of a given text, the inference the writer intended the reader to make may be unclear without the inclusion of a connective. For example, sentence (2) below could be interpreted as (3) or (4). One interpretation indicates that tourism is responsible for the endangerment of the monkeys. The other interpretation is that tourism has increased due to the endangerment of the monkeys—perhaps because the tourists want to see them before they go extinct. The use of a connective makes it clear which is intended without asking the reader to draw their own conclusions. In this case, I would not expect to see the inverse U predicted by the

elaboration hypothesis. Instead I would expect to see a linear pattern with comprehension improving as elaboration is constrained.

(2)The monkeys are endangered. Tourism on the rise.

(3)The monkeys are endangered because tourism on the rise.

(4)The monkeys are endangered, so tourism on the rise.

A finding of a linear pattern related to cohesion in this study would not disprove the elaboration hypothesis. However, it could suggest the effects predicted by the hypothesis are limited to answering questions about texts shortly after reading them and without much interference between the texts and the questions. Many of the studies cited above use a small number of texts with questions presented shortly after reading has been completed (Irwin, 1980; Linderholm et al., 2000; Maury & Teisserenc, 2005; McNamara et al., 1996; O'Reilly & McNamara, 2007; Ozuru et al., 2008; van Silfhout et al., 2015, Voss & Silfies, 1996). The reverse cohesion effect, then has mainly been found when interference with memory has been minimal. It may be that over a longer stretch of time, more constrained elaborations facilitated by connectives result in a more resilient memory trace and improved retention of the text. We further explore this alternative theory in the discussion.

1.4 Processing and retention of details incidental to inter-clause relationships

We consider one additional aspect of comprehension and memory for text. Besides affecting what is remembered and what is integrated, connectives may affect what is *not* remembered and *not* integrated. The presence of an explicit cue regarding a relationship among clauses may result in greater attention being shifted to that information, possibly at the loss of

attention to other parts of the sentence that are less relevant to the relationship. I term these parts of the clause that are not essential to understanding the relationship between the clauses: the incidental details. If connectives direct attention away from incidental details, I would expect that retention of details would diminish when connectives are present, especially if the detail comes after the connective. Further, I would expect that reading times for the incidental details would be faster and skip rates higher. By comparison, when a connective is not present, readers are not immediately aware of what is important and may attempt to integrate all information regardless of its relevance. This could lead to longer reading times on details when a connective is absent from the sentence and lower skip rates.

On the other hand, it is also possible that working memory load is decreased when discourse cues tell the readers how to integrate the clauses. If this is the case, I may see little effect of connective presence on online processing of incidental details within the passage, but retention of the detail should improve. This would mean that the pattern of retention found for inference memory should be similar to that found for incidental detail memory.

1.5 Measuring memory

Studies that found memory benefits for sentences containing connectives often used cued or free recall as primary measures of memory (Caron et al., 1988; Millis & Just, 1994; Murray, 1995, 1997). Kintsch (1988) proposed that such measures reflected memory for the text base and produced a superficial understanding of the text. Subsequent studies have found that short answer questions can successfully probe memory for the situation model (McNamara et al., 1996; O'Reilly & McNamara, 2007). However, van Silfhout et al. (2015) used a similar paradigm and

found that the wide variation of responses among the participants made it difficult to find reliable results; the authors suggested subsequent studies use a multiple-choice format. Further, in the series of studies conducted by McNamara and colleagues, accuracy for short-answer questions was low (often less than 50%), and as previously noted, that was after a brief delay. Such low accuracy would be compounded in this study in which participants read 120 different passages. Short-answer questions would have likely yielded results that were at floor. Instead I adopted a two-item forced choice task and used confidence ratings as a control against guessing. This method allowed participants to use recognition memory to help retrieve the memory trace and select the correct interpretation.

Presenting two possible answers also adds an opportunity for further interference. I hypothesized that if the elaboration hypothesis does not hold true when increasing the span of time between the text and the test, then additional elaborations formed when a connective is absent may interfere with the memory trace over time. This would make the introduction of an answer choice that incorrectly integrates the information from the text more tempting as it might overlap more with some of the elaborations stored with situation model, especially if the distinctions of how those elaborations relate together has decayed.

1.6 Summary of interests

This study tested three main hypotheses. (a) Connectives interfere with elaborative processing but aid comprehension such that retention results in an inverse U as predicted by the elaboration hypothesis. (b) Connectives provide focus to the relationship among ideas and reduce attention to and memory for material that is less relevant to that relationship. (c) Connective

position interacts with clause order to affect reading strategies. For example, in backward causal constructions when a connective occurs at the beginning of a sentence, readers may delay processing until they have accessed the cause.

2.0 Method

2.1 Power analysis

To determine an appropriate sample size, I conducted a power analysis using a Monte Carlo simulation with effect sizes generated by the memory outcomes for the first 12 participants (Lane & Hennes, 2018). It typically requires more participants to find a significant effect of a binary versus continuous outcome (Burgess, 2014), so I determined that the number of participants necessary to detect an effect with the binary outcome of accuracy on the forced-choice tasks would also be a sufficient number to detect an effect for the continuous outcomes of reading times. The primary variable of interest was the interaction of Connective Presence x Clause Order. The sample data had a small effect size of 0.07 for this interaction on inference memory. With such a small effect size, power could not be achieved even with 144 participants. However, the effect of the interaction on incidental detail memory was moderate at -0.40 and 80% power was achieved with 84 simulated participants. This sample size was also large enough to exceed 80% power for the main effects on inference memory. I therefore accepted 84 participants as a goal for the study.

2.2 Participants

Students (N = 85, 48 female, M_{age} = 18.81) at the University of Pittsburgh participated in partial fulfillment of a course requirement. All participants self-reported as native English speakers without reading disabilities and with normal or corrected to normal vision. During the

reading phase of the study, participants answered base comprehension probes. Low accuracy on these probes was thought to reflect low attention to the task, thus participants with less than 70% accuracy were excluded from all analysis (n = 6). One additional participant was excluded from only the memory analysis as their scores for both inference and detail memory fell below chance. This left 78 participants for the analysis of memory outcomes.

Several more exclusions took place for the eye-tracking data. Data files from the first three participants were lost due to a technical error. Further, because collecting memory outcomes did not require successful eye-tracking calibration, I allowed several participants to complete the study despite knowing their eyes were not calibrated accurately. This resulted in a high exclusion rate for the eye-tracking data. Four participants were excluded outright as experimenter notes reflected a complete inability to track their eye movements. I then conducted a systematic investigation into tracking quality of each trial for each participant. I explain this in detail below but for now highlight that this resulted in the removal of 21 participants, leaving us with 64 participants available for the analysis of reading.

Participants were asked to provide their verbal SAT or ACT scores at the end of the experiment. Participants were warned ahead of time that they would be asked for this information but that they could decline to provide it. Only 41 participants provided their verbal SAT score, M_{SAT} = 672 and 8 their ACT score, M_{ACT} = 30.9. While not enough participants provided exact scores to meaningfully apply their scores to a model, those who reported them were, on average, skilled readers. Average reported scores for both the SAT and ACT placed participants above the 90th percentile based on 2018 (ACT) and 2019 (SAT) rankings (The ACT Profile Report, National Graduating Class 2018; SAT Understanding Scores, 2019).

2.3 Apparatus

An Eyelink 1000 eye-tracker monitored the gaze location of participants' right eyes as they read. Spatial resolution of the tracker was better than 30' arc and it had a 1000Hz sample rate. Viewing was binocular with the monitor placed 55.88 cm from the participants eyes. Three characters equaled approximately 1 degree of visual angle. Text was presented in size 18 font with two line breaks between lines and a maximum line length of 80 characters.

2.4 Materials

2.4.1 Critical trial creation.

90 expository passages were created with the intention of keeping 60 following a norming study which I detail within the section describing the memory probes. All passages contained four clauses. The first and final clauses were held constant across conditions and were designed to simply introduce and conclude the topic. The center two clauses could be combined to make one sentence in the case of a connective being included in the passage or they could exist as two separate sentences in the case of the no connective condition. To avoid confusion about the differing number of sentences between conditions, I refer to these as the first and second critical clause.

Two examples of the stimuli are written out as they appeared in each condition in Table 1. For the middle-connective conditions I connected the clauses with *so* (cause-effect, CE) and *because* (effect-cause, EC). For the beginning-connective conditions I used *Because* (CE) and *The*

reason (EC). *The reason* is not categorized as a connective, but as there are no connectives that can stand on their own to begin a single sentence with a backwards causal structure in English, I considered *The reason* to be the best approximate. The semantics conveyed by *The reason* are similar to *because* (Hajičová, 1984), and the Prague Dependency Treebank lists *The reason* and other similar multiword phrases as secondary connectives (Rysová & Rysová, 2015). *The reason* is a connective in the sense that it cues the reader as to the relationship between two clauses. It differs from other connectives in that the two words can stand alone to reference an entire clause mentioned earlier in the text; i.e., it is possible to say *The reason is* … in which *The reason* is not followed by any further information about the effect (Rysová & Rysová, 2015). This means the reader may assume that the effect that follows *The reason* references given information and the cause new information. I return to the special case of *The reason* in the general discussion.

A few additional constraints were placed on the critical clauses. They always contained a causal relationship but never relied on anaphoric reference to the other clause. This restriction was put in place to ensure the clauses could be reversed and still be considered coherent. Although the clauses did occasionally use the same words, these were not referencing each other (e.g., in Table 1, *city* in the two critical clauses about *Timbuktu* reference the first sentence rather than each other).

The topics of the passages included animals, famous people, places, events, health, and antient myths with the initial 90 passages spread evenly across all domains. The content for each passage was largely based on facts but modified at times to fit the constraints of the experiment (e.g., Timbuktu is actually North of the Niger River, but the word *North* was used in several other passages which barred it from use as an incidental detail, so *South* was used instead). After completing the study, participants were informed that not all of the passages they read were factually accurate.

The final set of 60 passages had a mean length of 52.5 words with a mean sentence length of 16.1 words. This broke down to a mean of 12.9 words per sentence when a connective was absent and 17.7 words per sentence when a connective was present. The lengths of the effect and cause clauses differed by less than one word on average (M_{cause} = 12.9, M_{effect} = 13.3)

Each critical clause contained several interest areas (IAs) for eye-tracking analysis. The IAs are marked by superscripts in Table 1 and are as follows:

Noun phrase[2]: Each of the two critical clauses began with a noun phrase two to three words in length (M_{length} = 13.80 characters). Because the noun phrase was always the area immediately following the connective and I expected effects from the connective to be strongest just following the connective (Canestrelli et al., 2013; van Silfhout et al., 2015), this became the primary IA. To control for effects from line breaks and proximity to the edges of lines (e.g., Kuperman, Dambacher, Nuthmann, & Kliegl, 2010), I ensured all noun phrases were never within 12 characters from the beginning or end of a line.

Start of the verb phrase[3]: The noun phrase was followed by the first two words of the verb phrase (M_{length} = 12.00 characters). I separated these two words from the rest of the verb phrase as a spillover for any effects of the noun phrase (e.g., Rayner & Duffy, 1986). However, while simultaneously controlling for the location of the noun phrase, it was not possible to ensure that these two words never occurred at the end, beginning, or across a line. Their location on the line was constant across connective locations, but when the clause order switched, their placement on the line varied. Although there were 60 passages, each passage contained two clauses, resulting in 120 total clauses. The start of the verb phrase ended up crossing the line boundary 21 times out of the possible 120. Because of the loss of precision resulting from the line placement, I use this IA only to support findings within the noun phrase.

End of clause[4]: The last two words in each clause made up the end-of-clause IA (M_{length} = 13.00 characters). As with the start of the verb phrase, this IA occurred at the beginning, end, and across lines (n = 18 clauses crossed the line boundary). This reduces the precision of the findings for this IA. Further, the end of the clause is a unique area for processing within the sentence (Millis & Just, 1994; Rayner, Kambe, & Duffy, 2000). Reading times often increase at the end of the sentence or clause if it is marked by punctuation (Just & Carpenter, 1980; Warren, White, & Reichle, 2009). I would therefore not expect the end of the clause to show the same reading patterns as an IA earlier in the sentence. Additionally, in our materials, the end of the first critical clause sometimes included punctuation and sometimes did not making it difficult to disambiguate the effects of connective presence from the effects of punctuation (Hirotani, Frazier, & Rayner, 2006; Warren et al., 2009). The end of the second critical clause is a more stable location of analysis in our materials, as for all conditions, the second critical clause ends in a period. However, the differing sentence lengths introduce confounding factors and make it difficult to differentiate the effects of clause order and connectives versus just combining two sentences into one. I therefore excluded this area from interpretation. However, for transparency, models related to the effects at the end of the clause are reported in Table 3 in Appendix A.

Incidental Detail[5]: One detail was included in each passage that was deemed incidental; i.e., not critical to understanding the relationship between the clauses. The incidental detail was added to the prepositional phrase of either the cause or the effect and was counterbalanced to ensure half of the causes and half of the effects contained the incidental detail (M_{length} = 6.80 characters). The detail never appeared in any other passage. As this was an area with a priori predictions regarding the effects of connective presence and location on reading times, placement of the detail on the line was controlled so that it was never less than 12 characters from the

beginning or end of a line. The detail also never occurred as one of the first two words following the noun phrase or as one of the last two words in a clause.

All other areas[1]: These areas were not included in any analysis. The first and final sentence existed to provide context to the passage and were held constant across conditions. The verb phrase (M_{length} = 39.9 characters) was not analyzed because effects were expected to occur in the region immediately following the connective and no a priori predictions were made about specific effects within later parts of the verb phrase before the end of the clause. Instead, when looking for global effects of the manipulations, summed reading times across all IAs within the clause are used to get clause level effects.

Table 1 Example passages

	Cause - Effect	Effect - Cause	Cause - Effect	Effect - Cause
Connective Absent	[1]The red-shanked douc is an endangered species of monkey. [[2]Increased tourism] [[3]has created] [1]a greater need to develop previously [[4]forested areas.] [[2]The primates' habitat] [[3]has shrunk] [1]in Indonesia[5] to dangerously [[4]low levels]. [1]British conservationists are attempting to tag and track the remaining populations.	… The primates' habitat has been shrinking down in Indonesia to dangerously low levels. Increased tourism has created a need to develop previously forested areas. …	Timbuktu is a city located in the country of Mali in North Africa. The ancient city was built directly to the south of the Niger River. Early traders used the city as a hub for the exchange of exotic goods. Rumors about the city spread along the river and enshrouded it in mysticism.	… Early traders used the city as a hub for the exchange of exotic goods. The ancient city was built directly to the south of the Niger River. …
Connective Beginning	… Because increased tourism has created a need to develop previously forested areas, the primates' habitat has been shrinking down in Indonesia to dangerously low levels. …	… The reason the primates' habitat has been shrinking down in Indonesia to dangerously low levels is increased tourism has created a need to develop previously forested areas. …	… Because the ancient city was built directly to the south of the Niger River, early traders used the city as a hub for the exchange of exotic goods. …	… The reason early traders used the city as a hub for the exchange of exotic goods is the ancient city was built directly to the south of the Niger River. …
Connective Middle	… Increased tourism has created a need to develop previously forested areas, so the primates' habitat has been shrinking down in Indonesia to dangerously low levels. …	… The primates' habitat has been shrinking down in Indonesia to dangerously low levels because increased tourism has created a need to develop previously forested areas. …	… The ancient city was built directly to the south of the Niger River, so early traders used the city as a hub for the exchange of exotic goods. …	… Early traders used the city as a hub for the exchange of exotic goods because the ancient city was built directly to the south of the Niger River. …

2.4.2 Memory probes.

For each passage, one probe and two answer choices were constructed to measure memory for bridging inferences. Example probes and answers are depicted in Table 2. One answer always contained the true causal relationship between the two clauses. The other always contained an incorrect inference. The answers to the inference probes could take several forms. In some cases, the causal relationships were simply reversed so that the cause was written as the effect. In other cases, the first or final sentence was attached in a causal, temporal, or adversative relationship to one of the middle clauses. In all cases, something was added to the answer choice that would render it incorrect, either because the information in the statement was not contained in the passage or because it contradicted the passage (e.g., trading did not start until after Timbuktu was a city).

Because the differences between the options were intentionally subtle, it was necessary to ensure that the incorrect answer would not be perceived as a second correct answer to some participants. In order to determine that the answers I deemed most reasonable were objectively the most reasonable, I conducted a two-phase norming study with a total of 38 participants. In the first phase I verified that participants could not guess the correct answer based on prior knowledge or through logic. 17 participants saw only the inferences probes and were asked to rate how likely they believed each answer was to be true on a scale from 0-100. I only accepted probes in which the difference between the ratings on each probe did not exceed 10 points in favor of the correct answer. 14 passages were excluded during this phase. Probes in which participants had no preference or strongly favored the incorrect answer were allowed to pass to the next phase of norming. For the passages accepted the mean difference in ratings was -2.27 in favor of the incorrect answer as shown in Figure 3.

The second phase of norming confirmed that the incorrect answer choice was not a likely interpretation of the passage. 21 participants, separate from those who participated in the first phase of norming, read each passage and beneath the passage the two inference probes were presented. Participants were asked to rate how likely each statement was to be true based on the passage. The difference scores always favored the correct answer, but only the 60 passages with the highest difference scores were retained. The mean difference score of the final 60 passages was 48.32, see Figure 3.

During the experiment, all inference probe questions began with the wording *Based on the passage about*, continued with a prompt to remind participants of the topic of the passage, and ended with the phrase *it is most reasonable to conclude.*

Table 2 Example memory probes

Bridging Inference Question	Based on the passage about the red-shanked douc it is most reasonable to conclude …	Based on the passage about Timbuktu it is most reasonable to conclude …
Correct	The red-shanked douc have been forced out of their habitat due to increased tourism.	Timbuktu became a popular city because its proximity to the Niger River made it a port of trade.
Incorrect	Tourism is increasing in some areas as people travel to see the red-shanked douc before it goes extinct.	Timbuktu was built near the Niger River in order to capitalize on the trade happening on the river.
Detail Question	Where is tourism on the rise?	What is the directional relationship of the Niger River to Timbuktu?
Correct	Indonesia	South
Incorrect	Cambodia	West

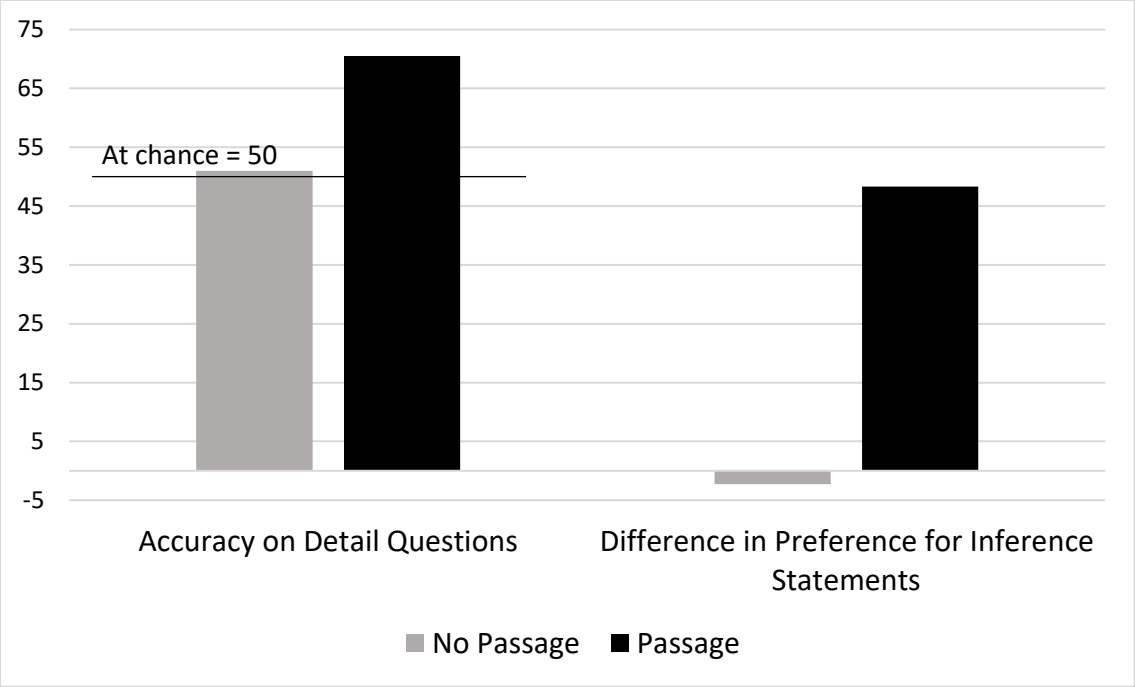

Figure 3 Norming results. Y-axis represents accuracy for detail questions and difference scores for inference probes. Black bars indicate greater sensitivity to the correct answer for participants exposed to the passages.

In addition to questions about bridging inferences, a question about the incidental detail from the passage was asked. Two examples are illustrated in Table 2. To account for any effects of familiarity (e.g., Yonelinas, 2002), incorrect details were words that had appeared in another passage, usually the filler trials. Again, I conducted two phases of norming. In the first phase, the same 17 participants who rated the inferences without reading the passages answered the detail questions. Mean accuracy was as it should be, at chance, $M = 51.00\%$. However, this was just the mean. For some questions, accuracy was as high as 80%. In these cases, I simply reversed the correct and incorrect answers thereby changing the details in the passages so that any bias favored the incorrect response.

For the detail probes, the second phase of the norming was to determine whether or not it was reasonable to expect participants to remember details that were not critical to understanding each passage regardless of the condition. Here the 21 participants who had read the passages were

given the probes for each detail only after they had finished reading all of the passages. Mean accuracy was 70.50%, indicating that the task was possible, see Figure 3.

During the experiment, a forced choice procedure was used with two probes presented for each detail and inference question. The order of the probes on the screen was randomized for each trial. Beneath each probe, participants rated their confidence in their answer on a scale from 50-100. The bottom of the scale was 50 because probability of a correct response was always a minimum of 50%. The confidence ratings were collected with the intention of using participants' confidence in the correct answer as the dependent variable.

All passages and probes used in the experiment are presentence in Table 6 of Appendix B.

2.4.3 Cohesiveness.

Passages were analyzed using Coh-Metrix (Graesser & McNamara, 2011; Graesser, McNamara, & Louwerse, 2003; Graesser et al., 2004) to get a general sense of their cohesiveness. Passages were written without use of referential cohesion between the two critical sentences so that cohesion depended on the presence of a connective. This was true, with referential cohesion averaging -0.22 without a connective and 0.38 with a connective on a standardized scale. As referential cohesion measures the extent of overlap in word and anaphor use between adjacent sentences, a negative rating when connectives are absent demonstrates that there was little use of referential language between the two critical sentences. The fact that the rating is positive when connectives are present reflects that the overlap between the critical clauses and the first and last sentence of the paragraph. Similarly, verbs could not be relied on to create cohesion, overall verb cohesiveness was rated -0.19.

2.4.4 Filler trials.

A second set of 60 passages were created to act as fillers and varied between 2-4 sentences. None of the filler trials presented an overt causal relationship. Instead, illustrative, adversative, additive, logical, and temporal relationships were used. An example filler is provided in sentence (5). A complete list of the filler passages is list in Table 7 of Appendix B.

(5) Most of Star Trek's science is based on the energy-matter conversion hypothesis. When in deep space, the ship's energy shield protects it from a hull breach. If there is a breach, the same energy can be bounded into matter to repair the hull. Although its application is fictional, the principle is rooted in science.

Comprehension questions were created for 11 of the filler passages to ensure participants were reading and maintaining focus throughout the experiment. The number was settled upon to allow probes to occur approximately every 10-15 trials. The number of probes used during the experiment was kept low as the time spent reading was already taking 40-60 minutes and increasing attention checks may have exhausted participants. A list of the questions is provided in Table 5 of Appendix B. The questions were presented within 10 trials of the passage they were probing but never immediately following a passage to ensure that participants were reading to retain what they had read.

Responses to the first probe were not recorded due to technical error. Participants performed poorly as a group on two questions (4 and 9) which suggested these questions were unclear and they were thus discarded. This left us with eight questions to determine participants focus during reading. Average accuracy on these eight questions for the participants included in the study was 90.80%.

2.4.5 Practice trials.

Two of the rejected critical trials were used as practice trials. Both trials were presented in the effect-cause order. One had a connective in the middle and for the other no connective was present. This set up ensured participants had been exposed to the condition believed to be most difficult due to its low cohesion. For the practice trials, participants were asked comprehension questions about the passages as soon as they finished reading the passage and feedback concerning their accuracy was provided. The comprehension questions were identical to the type they would be asked at the end of the task. One detail and one inference question were asked for each practice passage. Practice passages and comprehension questions are in Table 4 of Appendix B.

2.5 Procedure

A 3 x 2 repeated measures design was used, so with 60 critical items, participants saw 10 passages in each condition. The order of the passages was randomized before the start of the study, but then held constant across all lists and participants. Participants placed their chin on a chinrest and their forehead against a forehead rest in order to minimize head movements. Calibration was then completed and validated. If validation of the calibration could not be reduced to below 1° of error for each point, a note was made but the participant was still run. Calibration was checked every five trials and recalibration occurred as necessary.

After initial calibration, the instructions for the task were presented to participants in text and verbally. They were told that they would read 120 brief passages and that they should read each passage once for comprehension as after they were finished they would be asked to answer

comprehension questions about important concepts and details from the passages. They were also advised that before each passage would be shown, a fixation dot would appear in the upper left corner of the screen and that they should look to this dot. The passage was displayed only after they had focused on this marker and the marker always appeared above and to the left of the passage. Further, they were advised to look at a dot in the lower righthand side of the screen when they were finished.

They then read the two practice passages and answered the practice questions. Participants were told that the questions at the end of the task would be similar to the ones they had just answered. They were also told that they would be asked periodic comprehension questions throughout the task but that these questions would be different in nature from the questions at the end of the task.

As it was a long task, participants were offered breaks every 30 passages. After reading all 120 passages, participants were directed to a new computer and completed 60 inference memory probes in the same sequence in which they had read them followed by 60 detail memory probes also in that same sequence to hold time elapsed between a given passage and its probe roughly constant. Each question had a retroactive confidence scale below it to control for guessing. Participants were instructed to rate how confident they were that the option they selected reflected what they read in the passage. The range of the scale, from 50-100, was pointed out and explained to participants.

In total, the study took between 90-120 minutes with reading taking participants between 40-60 minutes.

2.6 Analytical strategy

As explained above, the core areas of a priori interest were the noun phrase of each clause and the incidental detail. Supplemental analysis of the start of the verb phrase is included in the analysis only to show its consistency with the findings from the noun phrase and is presented with the caveat that there are differences in location on the line between items and between clause order conditions. I further include analysis of each clause as a whole as a secondary means to support the analysis at the noun phrase. Because eye-tracking experiments are vulnerable to Type I error stemming from multiple comparison (Orquin & Homqvist, 2017; von der Malsburg & Angele, 2016), I do not devote time to interpretation of marginal effects ($.10 > p > .05$) and only consider analyses of supplemental regions when they are able to further understanding of the effects in the core IAs.

All statistical tests were carried out in R Project for Statistical Computing with the packages *lme4* (Bates, Maechler, Bolker, Walker, 2015), *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2017), glmmTMB package for beta regression (Brooks et al., 2017), and emmeans for simple effects (Lenth, 2019).

2.6.1 Memory analysis strategy.

I analyzed two models, one for incidental detail memory and one for inference memory using mixed effect models. Confidence in the correct answer replaced accuracy as the dependent measure in both models. This allowed us to control for guessing and use a more sensitive, continuous scale (Burgess, 2014). Confidence in the correct measure was calculated using a combination of the participant's actual accuracy on the question and their confidence rating. If

their response was correct, their score became their confidence in their answer. If their response was incorrect, their score became 100 minus their confidence in their answer. This meant that if the participant reported that they were guessing by providing a confidence score of 50, their score for the answer became 50 regardless of whether they happened to click the correct response. On the other hand, if their confidence was 75, the score remained 75 if they selected the correct answer and became 25 if they selected the incorrect answer. This change in scale resulted in lower overall scores as it successfully accounted for guessing, but it did not change the pattern of results. Figure 4 shows the difference between accuracy and confidence scores for the conditions of Connective Location and Presence. Table 3 shows the precise values and difference between scores.

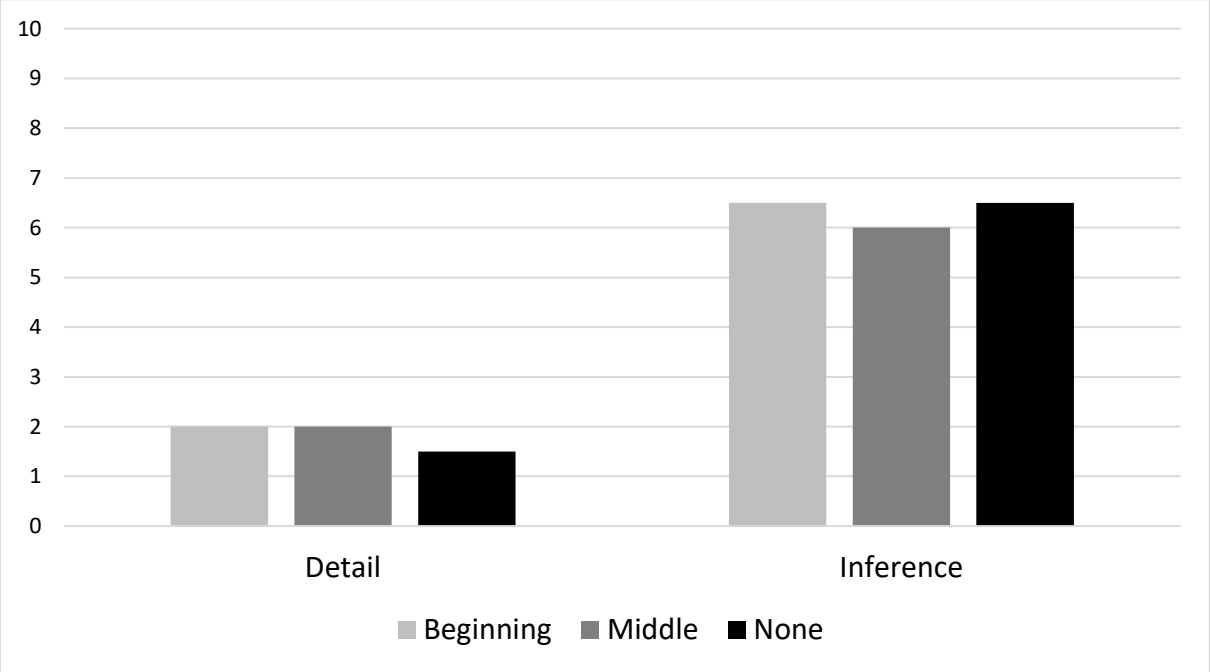

Figure 4 Accuracy versus confidence. Y-axis reflects the difference between mean accuracy and mean confidence in the correct answer. Positive values reflect higher scores for the accuracy measure.

Table 3 Norming data. Mean accuracy compared with mean confidence in the correct answer for each condition

Connective Location	Clause order	Detail accuracy	Detail confidence in correct answer	Detail change in score	Inference accuracy	Inference confidence in correct answer	Inference change in score
Beginning	Cause-Effect	61.40	59.80	1.60	78.30	70.50	7.80
Middle		63.40	60.30	3.10	76.90	70.50	6.40
Absent		63.80	60.70	3.10	71.80	65.20	6.60
Beginning	Effect-Cause	63.50	61.00	2.50	73.90	67.90	6.00
Middle		60.80	60.60	0.20	75.80	69.40	6.40
Absent		59.70	57.50	2.20	67.80	61.00	6.80

The new scale resulted in a non-normal distribution of results with many responses approaching the boundaries of 0 and 100. Linear regression requires the assumption of a normality of the dependent variable, so I used Beta regression which can handle the entire family of beta distributions and is robust against bounded data as it does not predict outcomes above 1 or less than 0 (Ferrari & Cribari-Neto, 2004). To use Beta regression, I moved our data to a 0-1 scale by dividing all values by 100, and as the glmmTMB package in R does not allow values of 0 or 1, I changed the 0 values to 0.0001 and the 1 values to 0.9999 which were the lowest and highest values accepted by the function.

Fixed effects for the memory models included Connective Presence/Location and Clause Order. Clause Order was contrasted coded to obtain results analogous to an ANOVA. Connective Presence/Location was treatment coded to compare connective presence to its absence and the effect of a connective at the beginning of the sentence to the effect of one in the middle of the sentence. Random effects were included for items and participants. The maximal random effects would not converge across all models, so in all cases I used the maximum structure supported by the data (Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017).

It is possible that if participants remembered the bridging inference, they would also be more likely to remember the incidental detail. If this was the case then any effect of the manipulations on outcomes for incidental details could just be because these manipulations also affect outcomes for the inferences. To account for this, I added the outcome variable for the associated inference memory probe to our models for detail memory. Any effect of the manipulations on confidence in the correct incidental memory is then an effect above and beyond the effect of having encoded a better representation of the passage as a whole.

2.6.2 Reading analysis strategy.

Continuous variables of first pass, go past, and total duration were analyzed using mixed effects models. In all cases, the data was right skewed, so the log of the values was used in place of raw scores. As the skip and regression out are binary outcomes, logistic mixed effect models were used for these variables. I define the measures of reading as follows:

First pass: The duration of time from which the participant's eyes entered the IA to the time their eyes left the IA either to the left or to the right.

Go past (regression duration): The duration in time from which the participants eyes first move into an IA to when their eyes leave the IA to the right.

Total time: The sum time participants spent with their eyes directed at the IA, including first pass, go past, and any additional refixations of the IA.

Skips: A binary variable based on whether or not the reader fixated a later IA before they fixated the target IA if they fixated on it at all.

Regressions out: A binary variable based on whether the reader moved their eyes to the left out of the IA during first pass reading.

Fixed effects of the reading models included Connective Presence/Location, treatment coded as in memory models. All models also included the control variable of IA length in characters which was mean centered and the Serial Position of the IA within the passage (i.e., in the 1st or 2nd critical clause). Clause Order was also included as a fixed effect for all IAs except the incidental detail. For detail models, there was only one IA per passage whereas for the noun phrase and start of the verb phrase, there are two IAs per passages, one in each clause. As a result, for detail models, the interaction between Clause Order and Serial Position of the IA would have created redundancies in the model. I thus replaced Clause Order with the variable of Clause Type containing the detail (cause versus effect)[4]. All non-continuous fixed effects aside from Connective Presence/Location were contrast coded.

One additional fixed effect was used in models predicting first pass and total time for the noun phrases. The noun phrase spanned the first two or three words of each clause. This meant that in no connective sentences, the noun phrase was the first phrase of the sentence, but in connective conditions, the noun phrase was one or two words further into the sentence. Serial word position within the sentence can affect reading times (Ferreira & Henderson, 1993; Haberlandt, 1982). In particular, reading times early on in the sentence tend to be longer than those later in the sentence (Kuperman et al., 2010). To account for this, I averaged each participant's reading times for all noun phrases that occurred at the start of a sentence—excluding the first sentence—in the filler passages divided by the number of characters in the noun phrase

[4] Although I did not expect Clause Type or Clause Position to be main effects in memory models, I did verify this in an early model testing. I found only the effect reported by their interaction which is explained by the variable of Clause Order.

(*M* = 36.40 per character for first pass and *M* = 49.80 per character for total time). I then repeated this process for every area in the filler trials that was not at the start of the sentence (*M* = 27.00 per character for first pass and *M* = 35.60 per character for total time). These reading times were used to predict expected reading times for the noun phrases in the critical trials. Times taken from the start of the sentence in the filler trials were used to predict times on the noun phrases in the critical trials which truly occurred at the start of a sentence (i.e., no connective and 1st noun phrase in middle connective conditions). Times taken from the rest of the words in the filler passages were used to predict expected reading times on noun phrases in critical trials which followed a connective (i.e., beginning connective and 2nd noun phrase in the middle connective conditions). Predicted total time following a connective was -63.90 ms faster on average than the actual and 22.60 ms longer on average when the noun phrase did not follow a connective. The difference for first pass time skewed longer in general, with the predicted time following a connective 3.22 ms longer than the actual time and the predicted time without a connective 30.20 ms longer than the actual time. In order to put the predicted times on the same scale as the dependent variables, I use the log value of the predicted reading times in applicable models. Including log predicted reading times reduced variance due solely to serial word position within the sentence.

Again, I included random effects for participants and items. In all cases, the maximal random effects structure failed to converge, and so the most maximal structure supported by the data was used.

3.0 Results

3.1 Memory results

Trials in which participants accidently pressed the space bar before reading (n = 11) were excluded from analysis.

3.1.1 Details.

I hypothesized that drawing attention to the relationships within the text through inclusion of a connective or use of forward causal structure would result in less attention to incidental details that were not critical to understanding the broader relationship. Alternatively, it is possible that when the relationship among the clauses is easier to process through the inclusion of a connective, incorporation of an incidental detail into the overall situation model for the text becomes facilitated. Consistent with the alternative theory, as participants' confidence in the correct inference answer went up, their confidence in the correct detail also went up by 1.68 times[5] (95% CI:[1.53, 1.68]), z = 7.95, p < .001. If readers were better able to retain the relationships among the clauses, they were better able to commit incidental details to their memory.

There were no main effects of connective location, presence, or clause order. However, there was an interaction between Connective Presence and Clause Order such that confidence in

[5] Beta coefficients in all logit model tables represent log odds. In order to facilitate interpretation, within the text I report the odds; i.e. the exponential value of the log odds.

the correct answer was 0.81 times lower (95% CI:[0.72, 0.91]) when there was no connective and a backward causal structure was used, z = -2.81, p = .005. As is clear from Figure 5, either clause order or connective presence was sufficient to improve memory for incidental details, but their effects were not superadditive. This supports the alternative model that when sentences are easier to process, incorporation of details into the representation of the passage is facilitated. The full model is reported in Table 4.

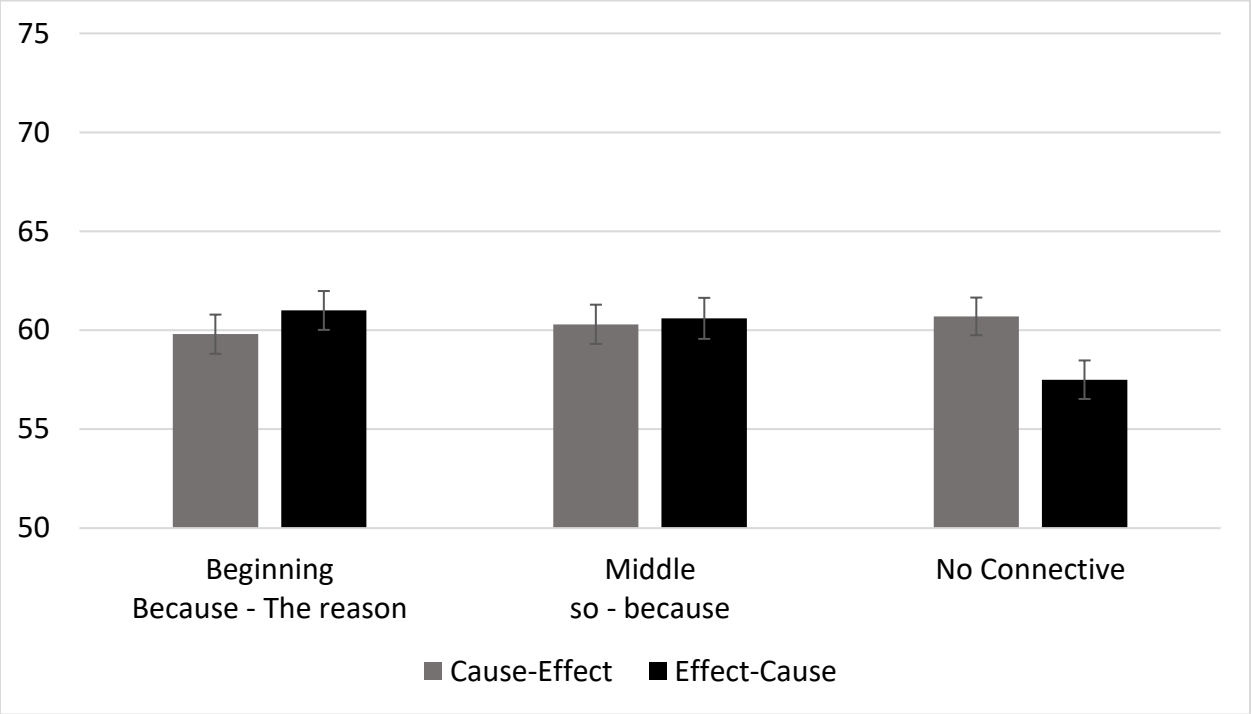

Figure 5 Mean confidence in the correct answer for detail probes. Error bars represent standard error (SE) across subjects.

Table 4 Fixed effects for confidence in the correct detailfrom a multilevel Beta regression model

	$\hat{\beta}$	SE	Wald *z*	*p*
Intercept	0.17	0.08	2.00	.05 *
Connective Presence	0.04	0.04	1.12	.26
Connective Location	-0.004	0.04	-0.08	.93
Clause Order	0.03	0.05	0.56	.58
Confidence in Correct Inference Answer	0.52	0.07	7.95	< .001 ***
Connective Presence x Clause Order	-0.21	0.06	-2.81	.005 **
Connective Location x Clause Order	-0.06	0.08	-0.68	.50

3.1.2 Inferences.

The main effects suggested that contrary to expectations, cohesive devices facilitated retention of bridging inferences. Confidence in the correct inference increased by 1.34 times (95% CI:[1.20, 1.49]) when a connective was present, $z = 5.06$, $p < .001$ and by 1.12 times (95% CI:[1.02, 1.122]) when the sentences contained a forward causal structure, $z = 2.47$, $p = .01$. Our primary interest was in the interaction, though, not the main effects. I expected that connective presence would interact with clause order such that maximal performance would occur in conditions with a connective and a backward causal structure. Further, performance was expected to be weakest in conditions containing a connective and a forward causal structure.

The first part of the hypothesis held true. Connective presence mitigated the harmful effects of backward causal structures on retention of the relationships from the text. The interaction between connective presence and clause order decreased the overall gap in performance based on clause order by 0.84 times (95% CI:[0.72, 0.97]), $z = -2.46$, $p = .01$. However, as is clear

from Figure 6, the reduction of the gap in performance based on clause order was due only to increased performance when a connective was present in a backwards causal structure. Contrary to predictions, performance improved and was actually strongest when a connective was present in a forward causal structure. The full set of results are presented in Table 5.

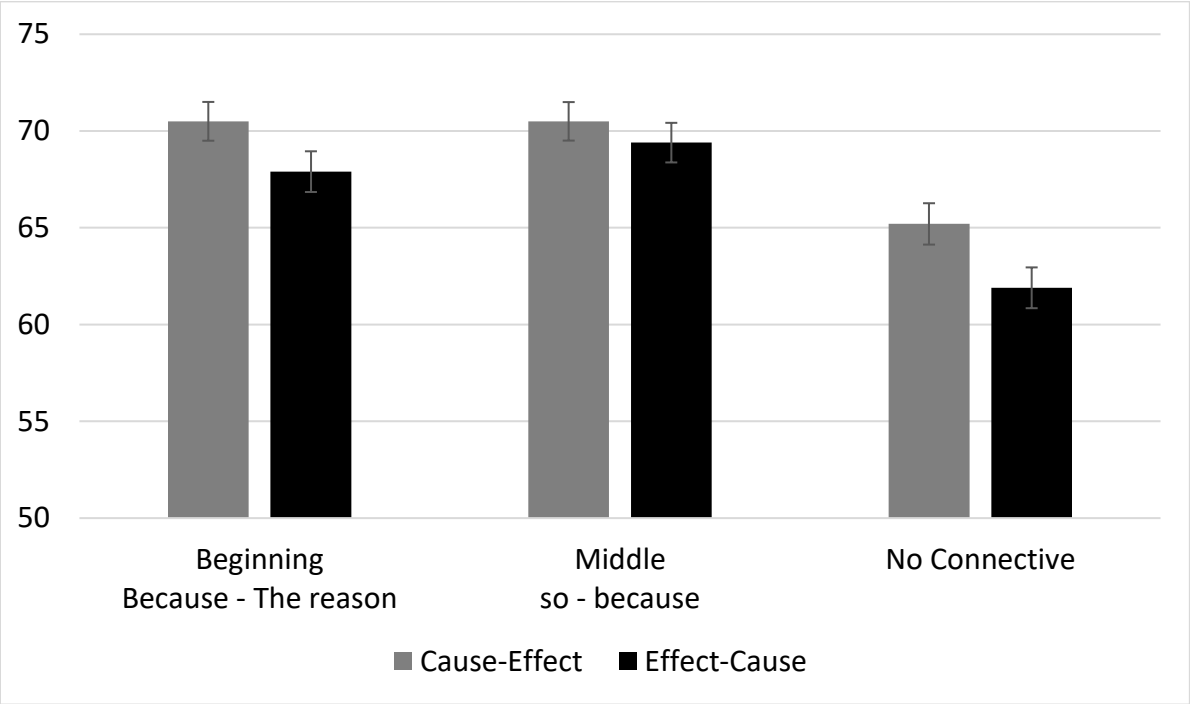

Figure 6 Mean confidence in the correct answer for inference probes. Error bars represent SE across subjects.

Table 5 Fixed effects for confidence in the correct inferencefrom a multilevel Beta regression model

	$\hat{\beta}$	SE	Wald *z*	*p*
Intercept	0.71	0.06	11.70	< .001 ***
Connective Presence	0.29	0.06	5.06	< .001 ***
Connective Location	-0.01	0.05	-0.22	.82
Clause Order	0.11	0.05	2.47	.01 *
Connective Presence x Clause Order	-0.18	0.07	-2.46	.01 *
Connective Location x Clause Order	-0.06	0.09	0.75	.45

3.1.3 Reading times predict memory.

As I collected both reading times and memory outcomes, I ran a model to determine if the outcomes of memory performance could be predicted by log reading patterns. For each log increase in total time, confidence in the correct incidental detail increased by 1.10 times (95% CI:[1.02, 1.19]), $z = 2.52$, $p = .01$.

To understand the relationship between reading times and retention of the relationships within the passage, I consider summed reading times on each clause. Total time spent reading the first clause did not predict confidence in the correct inference, $p = .33$. However, as total time increased on the second clause, confidence in the correct answer declined by 0.90 times (95% CI:[0.83, 0.99], $z = -2.30$, $p = .02$.

3.1.4 Discussion of memory effects.

Memory for details and causal relationships within a text improved as the text presentation became more cohesive through the inclusion of causal connectives and utilization of a forward

causal structure. Further, although the incidental detail was not necessary to understand the relationship between the clauses, it was better retained if the relationship between the clauses was retained. Improved retention of the detail in cases where the relationship among the clauses is better retained suggests that when readers had created an integrated situation model of the text, it was easier to incorporate smaller details from the text into the model.

Further, the results from the memory analysis suggest that improving the cohesiveness of a text improves comprehension. This runs counter to the expectations stemming from the elaboration hypothesis (Myers et al., 1987) and continuity principle (Murray, 1997). Based on these theories and prior results (e.g., McNamara et al., 1996), connectives should have facilitated memory only when other elements of the text were discontinuous and therefore less cohesive and less easy to process (i.e., in a backwards causal structure). Instead, performance improved linearly with cohesiveness and was the highest for conditions with a connective and a forward causal structure. I outline possibilities for these findings in the general discussion and weigh the likeliness of each.

3.1.5 Discussion of reading times predicting memory.

As 21 participants were excluded from the eye-tracking results data, power for models using reading times to predict memory performance was greatly reduced. Though faster reading times on the second noun phrase and longer reading times on the incidental detail predicted improved memory, the reading patterns did not reliably interact with the experimental manipulations. As a result, causal inferences about the relationships between the reading patterns and memory outcomes cannot be made, and no further time will be devoted to interpreting these effects.

3.2 Eye tracking

3.2.1 Data cleaning.

Prior to our analysis, several steps were completed to ensure the data used in the models best reflected participants actual reading and not tracking errors. Fixations under 100 ms were merged with nearby fixations. Trials were removed in which the number of blinks exceeded the number of fixations (6 trials), fixation counts outside of text were greater than counts in the text (406 trials), two complete lines of the trial were without any fixations (11 trials), a blink occurred during the first pass reading time of noun phrase or detail and the first fixation following the blink was not a return to the same IA or the IA following it (98 trials).

After removing trials, I ensured all participants still had at least four trials remaining in each condition and eliminated eight participants who did not. Four trials was a natural cut off as all remaining participants had at least six trials for each condition left and no more than a two trial difference across conditions.

3.2.2 Reporting.

In all cases, I substituted reading times with log reading times as the raw data was right skewed. Effects sizes were thus in log space. I report the log effect sizes in the Tables, but effect sizes reported in the text were transformed out of log space in order to facilitate interpretation. Similarly, for logistic mixed effects model, the effects in the tables represent log odds, but I transform log odds to regular odds within the text. Complete models of the supplemental IAs are reported in Appendix A in Tables 1 and 2.

3.2.3 Incidental detail reading.

For the incidental detail, I considered first pass and total time on the word as well as skip probability. I expected that when a connective was present, attention to the relationships between the clauses would be promoted and that this would result in shorter processing times and higher skip rates for the incidental detail. Consistent with this hypothesis, connective presence reduced first pass reading times for the incidental detail by 0.97 times (95% CI:[0.93, 1.00]), $t(2950) = -2.20$, $p = .03$. Figure 7 shows that this effect existed primarily in the second clause though the interaction was not significant, $p = .15$. Effects on total time were not reliable, ps > .20. The full models are presented in Table 6 with means in Table 7.

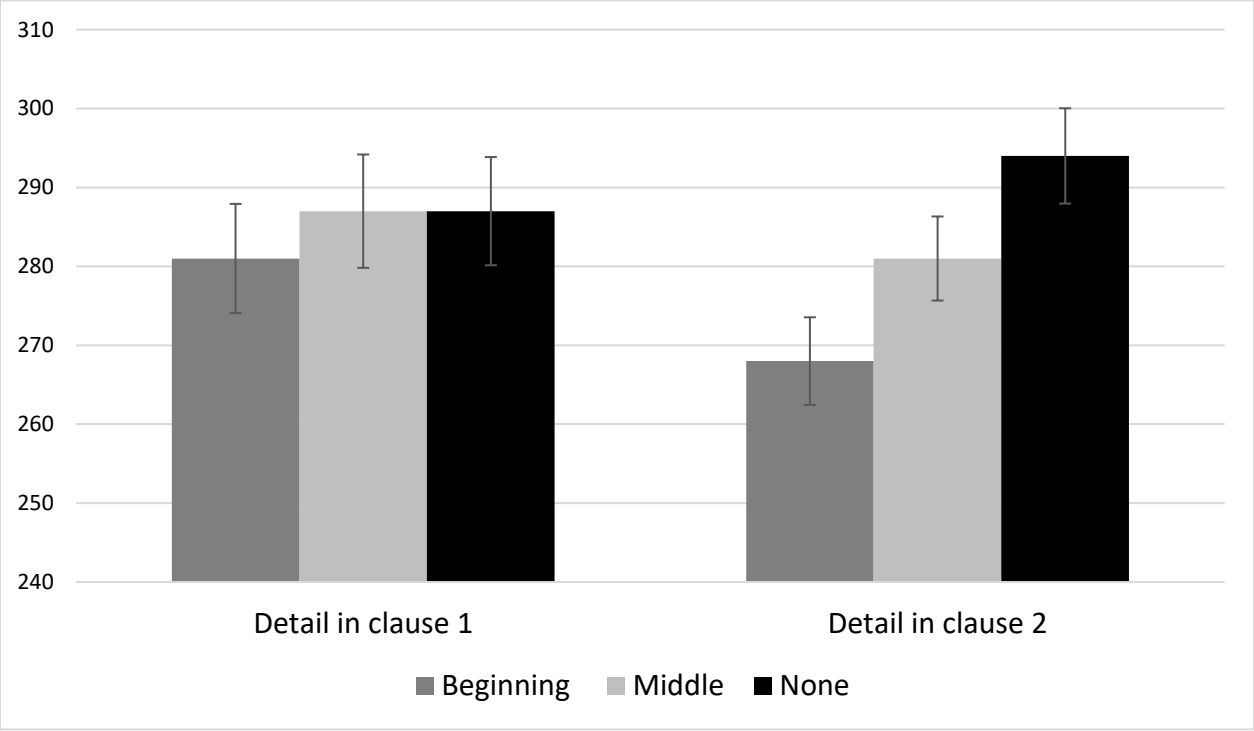

Figure 7 First pass reading times for the incidental detail based on connective location and clause containing the detail. Error bars represent SE across subjects.

We turn next to the odds of skipping the incidental detail. Odds of skipping decreased by 0.75 times (95% CI:[0.64, 0.88]) when the detail was in the first critical clause as compared to the second, z = -3.53, p < .001. Further, there was an interaction between connective location and clause type such that the odds of skipping a detail in the effect versus the cause were 1.57 times higher (95% CI:[1.06,2.32]) when the connective occurred in the middle of the sentence versus the beginning, z = 2.26, p = .02. The interaction is most clearly seen in Figure 8 with the exact mean numbers reported in Table 6, and fixed effects for the log odds of skipping reported in Table 7.

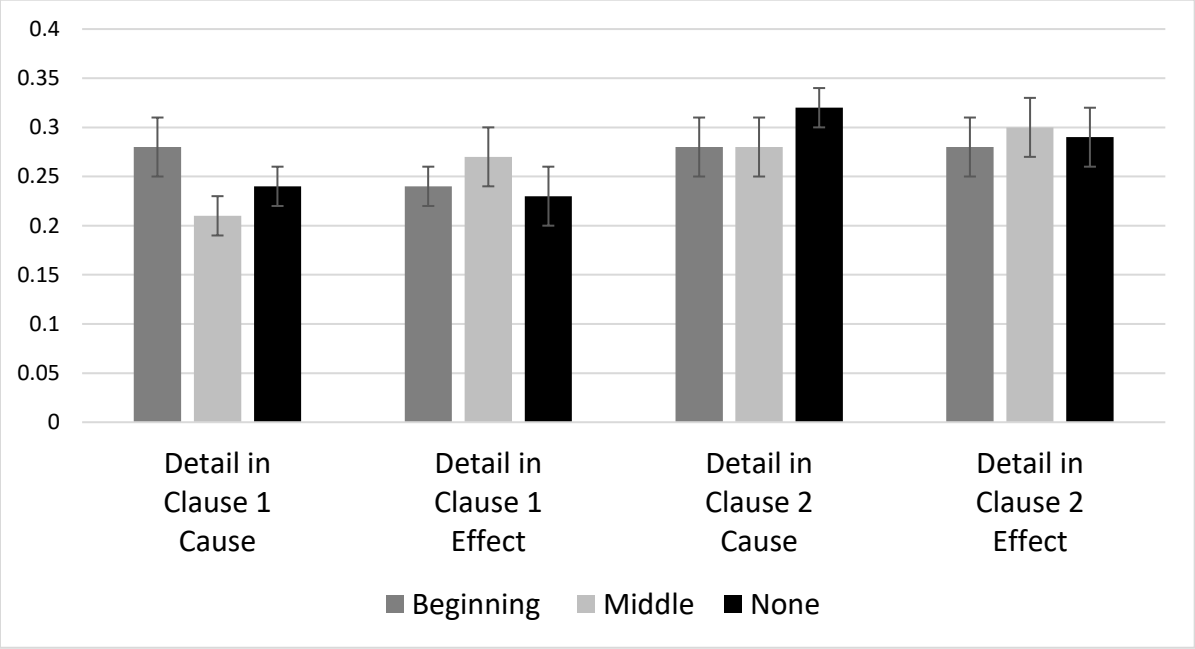

Figure 8 Skip rates for details based on the clause type (cause versus effect), the clause containing the detail (1st or 2nd), and the connective location. Error bars represent SE across subjects.

Table 6 Skip rates for incidental details

Connective Location	Clause	Clause 1 Skip Probability	Clause 2 Skip Probability
Beginning		0.28	0.28
Middle	Cause	0.21	0.28
None		0.24	0.32
Beginning		0.24	0.28
Middle	Effect	0.27	0.30
None		0.23	0.29

The results here partially align with our predictions. Reading times were fastest on the incidental detail following a connective and skip rates increased the most in the clause directly following the connective. However, to preview, the effects here align more broadly with processing times across the sentence; reading times decreased in general following a connective. Given the increased memory performance for incidental details when a connective was present, it seems unlikely that the faster reading times observed here are due to decreased attention. Instead, I interpret these results as consistent with the overall pattern of how connective presence affects reading times and not as evidence that the connective affects processing of details within the sentence uniquely. Similarly, although there is an interactive effect on skip rates, it does not include the predicted variable of clause position. Instead, it includes an interaction with clause type. As details that occur in the cause clauses are not the same as details occurring the effect clauses, some noise here is unsurprising and may be contributing to the results.

Table 7 Fixed effects for reading of the incidental detailfrom a multilevel logit model of skip rates and multilevel models of log first pass and total time for the incidental detail

	Skip Rate			First Pass			Total Time		
	$\hat{\beta}$	Wald *z*	*p*	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	*t*	*p*
Intercept	-4.09	-10.70	<.001 ***	6.02	77.11	<.001 ***	6.39	58.38	<.001 ***
Connective Presence	-0.004	-0.04	.97	-0.04	-2.20	.03*	-0.01	-0.61	.54
Connective Location	0.03	0.31	.75	-0.03	-1.70	.09 .	-0.02	-0.99	.32
Serial Clause Position	-0.29	-3.53	<.001 ***	0.01	0.64	.52	0.01	0.56	.57
Clause Type	-0.09	-0.70	.48	0.002	0.05	.96	-0.02	-0.49	.62
IA Length	-0.27	-8.06	<.001 ***	0.05	6.72	<.001 ***	0.06	6.14	<.001 ***
Connective Presence x Serial Clause Position	0.07	0.43	.67	0.05	1.43	.15	0.02	0.54	.59
Connective Location x Serial Clause Position	-0.04	-0.22	.83	0.05	1.28	.20	-0.03	-0.75	.45
Connective Presence x Clause Type	-0.15	-0.87	.39	0.001	0.02	.98	-0.003	-0.09	.92

Connective Location x Clause Type	0.45	2.26	.02 *	0.003	0.07	.94	-0.06	-1.27	.20
Serial Clause Position x Clause Type	-0.02	-0.09	.93	0.02	0.59	.55	-0.01	-0.15	.88
Connective Presence x Serial Clause Position x Clause Type	0.07	0.20	.83	0.02	0.25	.80	0.03	0.43	.66
Connective Location x Serial Clause Position x Clause Type	0.59	1.49	.14	-0.11	-1.42	.16	0.01	0.14	.89

3.2.4 Noun phrase reading.

The experimental manipulations had numerous effects on the reading of the noun phrase. In order to facilitate comprehension of this section, I discuss each effect in turn, starting with the effects on reading times before turning to the effects on the odds of regression out. The means for all effects listed here are presented in Table 8. For transparency, the table contains means for other IAs that I did not analyze. Model results for the noun phrase can be found in Table 9.

Table 8 Means for all IAs in the two critical clauses and for the last two words at the end of the passage

Connective Location	Clause	Clause 1 First Pass	Clause 2 First Pass	Clause 1 Regress Out	Clause 2 Regress Out	Clause 1 Go Past	Clause 2 Go Past	Clause 1 Total Time	Clause 2 Total Time
					Whole Clause				
Beginning	Cause – Effect	2452	2248	0.57	0.62	3413	3170	3374	2978
Middle		2635	2279	0.63	0.67	3618	3224	3623	2995
None		2542	2369	0.72	0.63	3713	3094	3503	3004
Beginning	Effect – Cause	2316	2292	0.61	0.70	3228	3230	3485	3054
Middle		2468	2234	0.60	0.60	3495	3117	3143	3054
None		2455	2454	0.66	0.63	3484	3485	3321	3251
					Noun Phrase				
Beginning	Cause – Effect	422	439	0.17	0.12	626	617	621	575
Middle		545	454	0.12	0.19	710	622	769	617
None		521	505	0.17	0.09	789	616	744	625
Beginning	Effect – Cause	391	451	0.25	0.22	606	647	569	630
Middle		489	391	0.13	0.14	571	664	682	539
None		492	509	0.15	0.09	689	655	716	672
					Start of Verb Phrase				
Beginning	Cause – Effect	412	397	0.14	0.15	526	562	581	526
Middle		414	409	0.16	0.15	569	576	578	542
None		411	440	0.16	0.16	559	590	581	565

Beginning	Effect – Cause	408	387	0.12	0.18	517	555	548	504
Middle		420	389	0.15	0.13	573	515	600	488
None		431	429	0.16	0.17	612	596	605	564
					Detail				
Beginning	Cause	274	261	0.19	0.20	426	376	360	352
Middle		287	269	0.20	0.24	415	472	383	366
None		286	288	0.22	0.18	470	395	380	367
Beginning	Effect	287	274	0.23	0.23	399	436	378	410
Middle		288	294	0.25	0.21	481	403	401	376
None		288	300	0.19	0.24	478	419	401	380
					End of Clause				
Beginning	Cause – Effect	373	363	0.21	0.26	595	591	486	453
Middle		394	360	0.23	0.24	638	577	520	441
None		372	348	0.32	0.27	661	546	486	444
Beginning	Effect – Cause	362	373	0.16	0.28	539	605	505	473
Middle		382	381	0.17	0.28	536	633	487	465
None		390	377	0.28	0.32	638	731	477	493

			End of Passage		
Beginning	Cause – Effect	436	0.49	1330	545
Middle		432	0.45	1276	543
None		422	0.44	1067	519
Beginning	Effect – Cause	442	0.45	1141	555
Middle		423	0.51	1212	542
None		441	0.45	1096	538

Table 9 Fixed effects for noun phrase readingfrom a multilevel logit model of regressions out and multilevel models of log first pass, go past, and total time

	First Pass			Total Time			Regressions Out			Go Past		
	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	Wald *z*	*p*	$\hat{\beta}$	*t*	*p*
Intercept	6.77	6.77	<.001***	7.05	6.64	<.001***	-1.75	-19.24	<.001***	6.39	190.08	<.001***
Connective Presence	-0.13	-4.71	<.001***	-0.12	-3.15	.002 **	0.38	4.92	<.001***	-0.07	-4.70	<.001***
Connective Location	-0.09	-4.20	<.001***	-0.07	-2.50	.01 *	0.28	3.45	<.001***	-0.03	-1.60	.11
Clause Order	0.05	4.00	<.001***	0.05	3.12	.003 **	-0.14	-1.96	.05 *	0.02	1.72	.09 .
Sentence (1^{st} or 2^{nd} critical)	0.01	0.60	.55	0.10	4.95	<.001***	0.21	3.06	.002 **	0.06	4.35	<.001***
Predicted Time	-0.10	-0.62	.53	-0.09	-0.54	.59						
IA Length	0.06	5.17	<.001***	0.07	5.66	<.001***	0.03	3.44	<.001***	0.06	26.75	<.001***
Connective Presence x Clause Order	0.05	2.01	.04 *	0.04	1.35	.18	-0.33	-2.17	.03 *	-0.002	-0.07	.95

Connective Location x Clause Order	-0.10	-3.13	.002 **	-0.14	-4.40	<.001***	-0.84	-5.13	<.001***	-0.17	-4.92	<.001***
Connective Presence x Sentence	0.08	2.68	.007 **	-0.02	0.41	.68	-0.73	-4.72	<.001***	-0.04	-1.34	.18
Connective Location x Sentence	-0.27	-6.04	<.001***	-0.25	-4.26	<.001***	0.67	4.10	<.001***	-0.14	-3.88	<.001***
Sentence x Clause Order	-0.02	-0.93	.35	0.01	0.37	.71	0.02	0.15	.88	-0.02	-0.86	.39
Connective Presence x Sentence x Clause Order	-0.02	-0.42	.67	-0.05	-1.00	.32	-0.35	-1.15	.26	-0.13	-2.18	.03 *
Connective Location x Sentence x Clause Order	0.10	1.63	.10	0.22	-3.55	<.001***	0.70	2.14	.03 *	0.15	2.08	.04 *

3.2.4.1 Effects of connective presence.

Reading times are generally faster in sentences with connectives (Millis & Just, 1994; van Silfhout et al., 2015). This was the case in for most measures. When a connective was present, first pass reading time was 0.88 times faster (95% CI:[0.83, 0.93]), $t(1865) = -4.71$, $p < .001$, total time was 0.89 times faster (95% CI:[0.82, 0.96]), $t(2828) = -3.15$, $p = .002$, and go past time was 0.93 times faster (95% CI[0.90, 0.97]) , $t(6890) = -4.7$, $p < .001$, than when no connective was included in the passage. Further, this effect was not localized to the noun phrase. Reading times at the start of the verb phrase were faster when a connective was present for first pass, $\hat{\beta} = 0.95$ (95% CI:[0.93, 0.96]), $t(6830) = -4.62$, $p < .001$, go past $\hat{\beta} = 0.93$ (95% CI:[0.90, 0.97]), $t(6830) = -4.92$, $p < .001$, and total time $\hat{\beta} = 0.93$ (95 CI:[0.91, 0.95]), $t(6840) = -5.28$, $p < .001$.

As further support of a global effect of connective presence on reading times, summed first pass reading times for the entire sentence—excluding the connective itself—were 0.96 times faster (95% CI:[0.95, 0.98]), $t(7170) = -4.88$, $p < .001$, summed go past time 0.95 times faster (95% CI:[0.94, 0.97]), $t(7170) = -4.97$, $p < .001$, and summed total time 0.97 times faster (95% CI:[0.95, 0.99]), $t(7170) = -3.95$, $p < .001$.

3.2.4.2 Effects of connective location.

For the first noun phrase, when a connective occurred at the beginning of the sentence, first pass reading time was 0.91 times faster (95% CI:[0.88, 0.95]) than when the connective occurred in the middle of the sentence, $t(4154) = -4.20$, $p < .001$. This pattern held for total time, $\hat{\beta} = 0.93$ (95% CI:[0.88, 0.99]), $t(3590) = -2.50$, $p = 0.01$, but it was not reliable for go past time, $p = .08$.

Differences based on connective location did not reliably extend to the start of the verb phrase, ps > .46, but did hold for the sentence as a whole. Summed first pass time was 0.97 times

faster (95% CI:[0.93, 0.99]) following a connective at the start of the sentence versus in the middle. Summed total time and go past time for the clauses as whole were also both 0.97 times faster (95% CI:[0.95, 0.99]), $t(7170) = -2.84$, $p = .005$.

The main effects of connective location reviewed here likely reflect that when a connective begins a sentence, there is an immediate speed up in reading times across the clause, but when a connective occurs in the middle of the sentence, reading times for the first critical clause should resemble reading times when a connective is absent as the reader has not yet reached the connective. This would result in effects of reading time based on connective presence being likely to also persist in comparisons of connective location.

3.2.4.3 Effects of clause order.

First pass reading times on the noun phrase for forward causal structures were 1.05 times longer (95% CI:[1.03, 1.07]) than for the backward causal structures, $t(6950) = 4.00$, $p < .001$. The effect persisted in measures of go past times, $\hat{\beta} = 1.03$ (95% CI:[1.01,1.05]), $t(6980) = 2.21$, $p = .03$, and total time, $\hat{\beta} = 1.04$ (95% CI:[1.02, 1.06]), $t(60.25) = 3.12$, $p = .003$. Further, the effect existed for the sentence as a whole for first pass, $\hat{\beta} = 1.03$ (95% CI:[1.02, 1.04]), $t(7170) = 3.56$, $p < .001$, go past $\hat{\beta} = 1.02$ (95% CI:[1.00, 1.04]), $t(7170) = 2.33$, $p = .02$, and total time, $\hat{\beta} = 1.02$ (95% CI:[1.00, 1.04]), $t(7170) = 2.94$, $p = .003$, but it was not present at the start of the verb phrase, all ps $> .20$. A close analysis of the means suggested that this effect was driven primarily by difference in how the two causal structures are read when a connective is in the middle of the sentence. When a connective is absent or occurs at the beginning of the sentence, the mean differences between the two structures are small. I return to this point when I discuss the interactions with clause order.

3.2.4.4 Effect of serial clause position.

First past times for the noun phrase did not differ based on serial clause position, $p = .55$, but go past times were 1.07 times longer (95% CI:[1.05, 1.09]) for the noun phrase in the first critical clause versus the second, $t(6970) = 4.63$, $p < .001$, and total times were 1.11 times longer (95% CI:[1.06, 1.15]), $t(4092) = 4.95$, $p < .001$. The pattern partially extended to the start of the verb phrase where total time was 1.09 times longer (95% CI:[1.07,1.12]) in the first critical clause versus the second, $t(6800)=7.14$, $p < .001$. However, there were no significant differences in go past time for the start of the verb phase, $p > .11$.

Overall, the second critical clause was read faster than the first. First pass times for the entire first critical clause were 1.08 times longer (95% CI:[1.07, 1.10]) than the second critical clause, $t(7170) = 10.31$, $p < .001$. This general pattern remained true for go past time, $\hat{\beta} = 1.09$ (95% CI:[1.08, 1.11]), $t(7170) = 9.61$, $p < .001$, and total time, $\hat{\beta} = 1.12$ (95% CI:[1.10, 1.13]), $t(7170) = 13.76$, $p < .001$.

We note here that in all cases, the trend is for reading times to decrease in the second critical clause. This is consistent with a previous finding that reading times decreased as a function of serial sentence position (Norberg & Fraundorf, under review). However, despite this general trend, reading times reliably increased for the noun phrase of second critical clause in backward causal structures that begin with a connective. I return to this in our reporting of the interactions with connective location.

3.2.4.5 Interactions with connective presence.

Connective presence interacted with both clause order and serial clause position to affect reading times. For the first noun phrase, the difference in first pass reading times between the two

causal structures increased by 1.06 times (95% CI:[1.00, 1.11)] when a connective was present, $t(6981) = 2.01$, $p = .04$. Although the effect was not present at the start of the verb phrase, $p = .44$, it did hold for the sentence as a whole, $\hat{\beta} = 1.03$ (95% CI:[1.00, 1.07]), $t(7170) = 2.10$, $p = .04$. There were no further effects of go past or total time for the noun phrase, ps > .05.

The interactions between connective presence and serial clause position were more consistent. The difference between first pass reading times of the noun phrase in the first versus second critical clause increased by 1.08 times (95% CI:[1.02, 1.15]) when a connective was present, $t(6147) = 2.68$, $p = .007$, by 1.06 times (95% CI:[1.02,1.1]) for the start of the verb phrase, $t(6800) = 2.60$, $p = .009$, and by 1.06 times (95% CI:[1.03, 1.09]) for the clauses as a whole, $t(7170) = 3.61$, $p < .001$. Further, although the effect at the noun phrase was no longer reliable for total and go past time, ps > .20, differences in total time between the two clauses when a connective was present were 1.07 times greater (95% CI:[1.03,1.12]) at the start of the verb phrase, $t(6800) = 2.65$, $p = .008$, and 1.05 times greater (95% CI:[1.01, 1.09]) for the clauses as a whole, $t(7170) = 2.75$, $p = .006$. There were no further interactions with connective presence at the noun phrase, ps > .32.

These interactions suggested that when a connective was present, readers were more aware of the structure of the sentence and how the clauses related and were thus more affected by the structure. Further, the disparity in reading times between the sentences was more pronounced in connective sentences, perhaps because the reader was more aware of which sentence should receive their focus. In the next section, I turn to effects that may suggest that the way readers process text changes based on when they receive a cue as to the relationship among the ideas in the text; i.e., whether the connective occurs at the beginning or in the middle of the sentence.

3.2.4.6 Interactions with connective location.

Differences in reading time between the two causal structures were significantly smaller when a connective came at the beginning of the sentence versus in the middle. At the noun phrase, differences in first pass times were 0.91 times smaller (95% CI:[0.85, 0.96)], $t(6974) = -3.13$, $p = .002$, go past times 0.84 times smaller (95% CI:[0.77, 0.90]), $t(6980) = -5.02$, $p < .001$, and total time 0.87 times smaller (95% CI:[0.82, 0.92]), $t(6918) = -4.40$, $p < .001$. However, these effect were localized to the noun phrase and not present at the start of the verb phrase or in the clauses as a whole, ps > .05.

Serial clause position also interacted with connective location. The differences between reading times for the noun phrase based on serial clause position were 0.76 times smaller (95% CI:[0.71, 0.83]) for first pass, $t(4193) = -6.04$, $p < .001$, 0.85 times smaller (95% CI:[0.70, 0.92]) for go past time, $t(6970) = -4.49$, $p < .001$, and 0.78 times smaller (95% CI:[0.69, 0.88]) for total time, $t(3627) = -4.26$, $p < .001$. The effect on go past time persisted to the start of the verb phrase, $\hat{\beta} = 0.92$ (95% CI:[0.87,0.98]), $t(6800) = -2.32$, $p = .02$, and the clause as a whole $\hat{\beta} = 0.93$ (95% CI:[0.90,0.97]), $t(7170) = -3.28$, $p = .001$. The effects on first pass times, $\hat{\beta} = 0.93$ (95% CI:[0.90,0.96]), $t(7170) = -4.06$, $p < .001$, and total time, $\hat{\beta} = 0.92$ (95% CI:[0.88,0.95]), $t(7170) = -4.33$, $p < .02$, also persisted to the clause as a whole, but were not present at the start of the verb phrase, ps > .13.

There were several three-way interactions between connective location, clause order, and serial clause position. When a connective was in the middle of the sentence, differences in reading times on the noun phrase between the first and second critical clause remained relatively consistent across the two clause structures. However, when a connective occurred at the start of the sentence, the effects of serial clause position varied based on the clause order and showed reverse effects

from those found when a connective occurred in the middle of the sentence. The effects existed for first pass, $\hat{\beta}$ = 1.25 (95% CI:[1.11, 1.40]), $t(6912) = 3.55$, $p < .001$, go past time, $\hat{\beta}$ = 1.15 (95% CI:[1.00, 1.32]), $t(6970) = 2.05$, $p = .04$, and total time, $\hat{\beta}$ = 0.89 (95% CI:[0.79, 1.00]), $t(6970) = -2.00$, $p = .05$. However, they did not extend beyond the noun phrase into the start of the verb phrase or the clauses as a whole, ps > .05.

A comparison of the means in Figure 9 suggests that the patterns found when a connective was in the middle of the sentence are more similar to the patterns found when a connective was absent from the sentence than they are to when a connective was at the beginning. Further, with one small numerical but nonreliable exception, the only time reading times on the noun phrase were longer in the second critical clause as compared to the first critical clause was when a connective occurred at the beginning of the sentence. Further, this effect was most pronounced and consistent in the backwards causal structure. I hypothesized that readers would have faster reading times for the first clause when a connective occurred at the beginning of the sentence because they would be delaying processing of the effect until they reached the cause. I find support for this hypothesis in the three-way interaction, but to test it explicitly I turn to the simple effects.

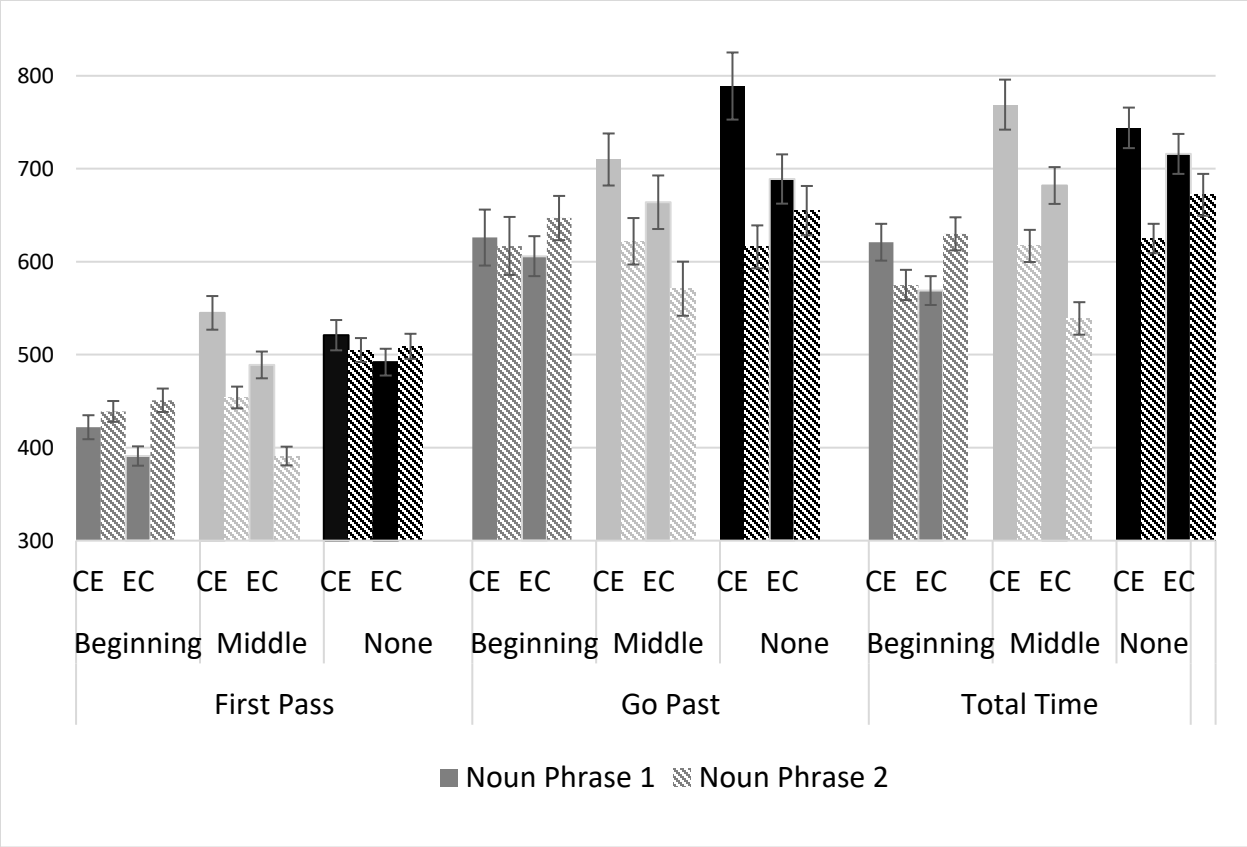

Figure 9 Mean times reading of the noun phrase for first pass, go past, and total times based on forward (CE) or backward (EC) causal structures interacting with location of the noun phrase and connective presence and location.

Fitting with our hypothesis, when the connective occurred at the beginning of the sentence and the clauses were in backward causal structure, first pass times were 0.90 times faster (95% CI:[0.85, 0.96]) for the noun phrase in first clause position versus the second, z = -3.45, p = .03. Further, when the connective occurred in the middle of the clause, first pass reading times of the noun phrase in the backward causal structure were 1.24 times longer (95% CI:[1.14,1.35]), z = 4.83, p <.001, go past times 1.22 times longer (95% CI:[1.13, 1.32]), z = 5.61, p < .001, and total times 1.34 times longer (95% CI:[1.19, 1.50]), z = 5.06, p < .001, in the first critical clause versus the second. The numerical trends in the no connective conditions for the backwards causal structures did not rise to significance following the Tukey correction, *ps* > .52.

One way to compare reading times on the noun phrase is to compare, as I did above, the reading times of the first noun phrase to the second noun phrase within the same structure. However, this results in comparing the noun phrase in the cause to the noun phrase in the effect and becomes a between items comparison. Therefore, I also compare reading times for the noun phrase when the effect is the first critical sentence versus the second critical sentence, and then I do the same with the cause clause. When a connective occurred in the middle of the sentence, reading times for the effect clause did not vary reliably based on serial clause position, *p*s > .80. However, first pass times for the cause clause were 1.34 times longer (95% CI:[1.22, 1.46]) when it was the first critical clause versus the second, $z = 6.46$, $p < .001$, go past times 1.28 times longer (95% CI:[1.19, 1.39]), $z = 7.10$, $p < .001$, and total times 1.43 times longer (95% CI:[1.27, 1.61]), $z = 6.10$, $p < .001$.

On the other hand, when a connective occurred at the beginning of the sentence, first pass reading times for the noun phrase in the effect clause were 0.89 times faster (95% CI:[0.84, 0.95]) in the first critical clause versus the second, $z = -3.8$, $p = .008$, but there were no reliable differences based on the serial position of the cause clause, *p*s > .30. This supports a conclusion that when readers know they will receive the effect before the cause, they speed up reading to reach the cause.

In sum, this means that when a connective was in the middle of the sentence, reading times reliably decreased for the second critical clause in most circumstances and especially if the second clause was the cause. When a connective occurred at the beginning of the sentence, the effect was either rendered unreliable in the case of a forward causal structure or reversed in the case of a backwards causal structure. Following a connective at the beginning of the sentence, readers read faster through the effect if it was the first critical clause and then more slowly through the subsequent cause. Based on a theory that readers prefer to process clauses consistent with their

temporal ordering, this suggests that readers change their reading strategies if they receive a processing cue indicating that the material will be presented outside of its iconic order.

3.2.4.7 Regression out.

In addition to predicting variation in the reading patterns based on clause order and connective location and presence, I also predicted diverging patterns of regression probability. I found support for this prediction. The odds of regressions out of the noun phrase were 1.46 times greater (95% CI:[1.25, 1.71]) when a connective was present as compared to when it was absent, $z = 4.92$, $p < .001$. Further, the odds of regressions out were 1.32 times greater (95% CI:[1.13, 1.55]) when the connective was at the beginning of the sentence versus in the middle, $z = 3.45$, $p < .001$. Forward causal structures decreased the odds of a regression out of the noun phrase by 0.87 times (95% CI:[.76, 1.00]), $z = -1.96$, $p = .05$. As a final main effect, regressions out for the noun phrase in the first critical clause were 1.23 times greater (95% CI:[1.08, 1.42]) than out of the second critical clause, $z = 3.06$, $p = .002$.

Nearly all of the variables had interactive effects. When a connective was absent from a sentence the difference in the odds of a regressions out based on clause order decreased by 0.72 times (95% CI:[0.54, 0.97]), $z = -2.17$, $p = .03$. When a connective was in the middle of the sentence, the odds of a regression based on clause order were reduced by 0.43 times (95% CI:[0.32,0.59]) as compared to when the connective was at the beginning of the sentence, $z=-5.13$, $p < .001$.

Connective presence and location interacted with sentence position. When a connective was present, the odds of a regression for the first critical clause versus the second critical clause were reduced by 0.48 times (95% CI:[0.36, 0.65]), $z = -4.72$, $p < .001$. When a connective was at

the beginning of the sentence, the odds of a regression out were 1.95 times greater (95% CI:[1.43, 2.67]) for the first critical clause, $z = 4.10$, $p < .001$.

Finally, connective location and presence interacted with both clause order and sentence order to affect outcomes. Whereas the middle connective condition showed a pattern of increased regressions out for the second noun phrase, the beginning connective conditions showed the reverse pattern, and this was further affected by the clause order with differences between the connective locations showing the largest difference for the forward causal structure, $z = 2.14$, $p = .03$. The means for the regressions out are displayed in Figure 10 and written out in Table 8. Model results are shown in Table 9.

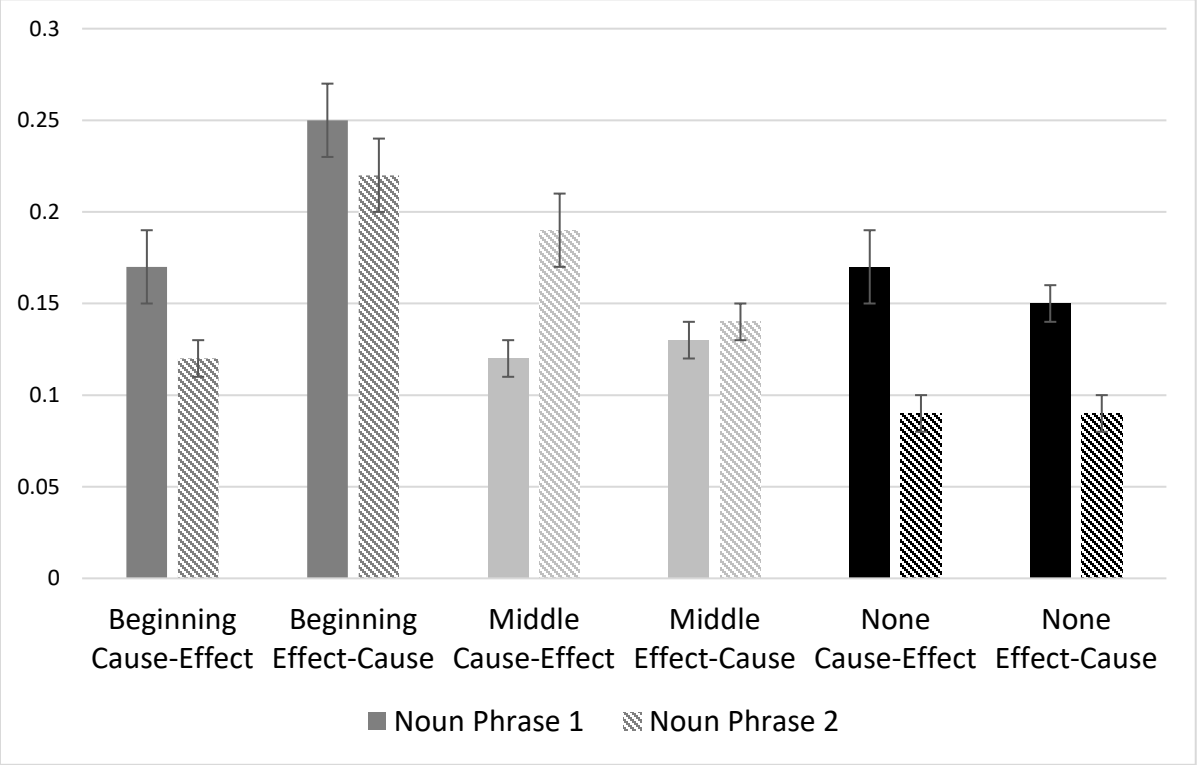

Figure 10 Probability of regression out the noun phrase. Error bars represent SE across participants.

In addition to expecting long reading times on the second noun phrase for backward causal structures when a connective occurred at the beginning of the sentence, I also expected this area to yield greater regressions out. The combination of faster reading times in the first clause leading

into longer reading times in the second and greater probability of regression back to the first clause would suggest readers delayed processing of the first clause until they could access the second. To understand this, I turn again to the simple effects.

First I note that for the noun phrase in the first critical clause, regressions out were significantly higher in the backward causal structure following a connective at the beginning as compared to the noun phrase in all other conditions, all *p*s < .02. This is likely related to the nature of *The reason*. This phrase suggests that what will follow is presupposed and may increase regressions back to the only possible origin of any presupposed information, the first sentence. The implications of a given-new structure for sentences beginning with *The reason* then did have specific effects on processing at the first noun phrase. However, regressions back to the first sentence and are not indicative of attempts to integrate the critical clauses, and so comparisons of regressions out of this area across conditions are less informative in general.

We turn then to look at regressions out of the noun phrase in the second critical clause as these may represent attempts at integration. A pattern emerged in the simple effects to show that when a connective occurred at the beginning of the sentence for the backward causal order, regressions out of the second noun phrase were 0.45 times less likely (95% CI:[0.33, 0.63]) than for the forward causal order, $z = -4.79$, $p < .001$. This effect numerically reversed for the middle connective condition: the odds of regressing out were numerically higher for the forward causal structure but did not reach significance following the Tukey correction, $z = 2.46$, $p = .37$. For the no connective condition, the odds of regressing out of the noun phrase in the second critical clause were nearly identical, $p > .99$. To further illustrate this difference across connective locations and presence, I point out that the odds of regressing out of when the clauses were in a backward causal structure was 1.72 times greater (95% CI:[1.25, 2.35]) if the connective came at the beginning

versus in the middle, $z = 3.43$, $p = .03$, and 2.99 times higher (95% CI:[2.11, 4.23]) than if no connective was present, $z = 6.16$, $p < .001$. Further, the odds of regressing out when a connective occurred at the beginning of the sentence and the clauses were in a forward causal order were 0.52 times lower (95% CI:[0.37, 0.73]) than when a connective occurred in the middle of the sentence, $z = -3.85$, $p = .007$, and not significantly different from when no connective appeared in the sentence, ps > .05.

For the most part, the effects from regressions out did not extend to the start of the verb phrase. However, the interactions between connective location and serial clause position persisted. Regressions out of the start of the verb phrase when a connective occurred at the beginning of the sentence in a backward causal structure were 1.54 times more likely (95% CI:[1.1, 2.15]) than when a connective occurred in the middle of the sentence.

3.2.5 Eye tracking discussion.

In general, and replicating prior results (e.g., Millis & Just, 1994; van Silfhout et al., 2015), the results of this study offer evidence that readers process clauses more quickly following a connective. Further regressions were less likely in almost all locations following a connective, with go past times when a regression did occur also being shorter. The one notable exception to this trend came from the noun phrase of the second critical clause where probability of regressions out were highest in the backwards causal structure when a connective occurred at the beginning of the sentence. Further, reading times for this noun phrase were numerically higher when a connective occurred at the beginning, but only reliably higher when the connective at the beginning of the sentence was paired with a backward causal structure.

This combination of findings suggest that when readers know they are about to receive information in a backwards causal structure, they speed up reading and delay processing of the effect clause until they reach the cause clause so they can process the effect in the context of the cause. Readers may be reordering their processing to fit an iconic sequence, even if it requires placing a greater strain on working memory as they hold one clause in mind and delay integration attempts until they have accessed the clause they know contains critical information to understanding what they already read.

Further, this points to a reader preference for cause clauses. When a connective came at the beginning of the sentence, readers read quickly to reach the cause before slowing down as they read it. When a connective came in middle of the sentence, readers showed a separate pattern of results based on clause order. In forward causal structures, the probability of regressing out of the second noun phrase spiked following the connective in the middle, but no such spike was seen for the backwards causal structure. Further, though reading times for the second noun phrase were faster than the first noun phrase when a connective came in the middle of the sentence, the difference in reading times based on clause order showed a greater reduction in reading time of the cause when the cause came in the second clause versus when the effect came in the second clauses. Essentially, reading times for the second noun phrase did not reduce as much in a forward causal structure as compared to a backward causal structure. I propose that in the forward causal structure, the reader discovers that they just finished reading the cause post-hoc, and this disrupts reading resulting in longer reading times and a greater probability of regression. On the other hand, when the reader finds out they just finished reading the effect there is less disruption as attention can be dedicated to the cause. I discuss the implications of this below in the General Discussion.

4.0 General Discussion

I considered the interactive role of two elements of causal cohesion: connective presence/location and clause order. There were three main hypothesis at the outset of the study: (a) I expected to find support for the elaboration hypothesis that when cohesion was too minimal or too maximal retention of text would be lower than when text was partly cohesive. (b) I expected the retention of details incidental to the core causal relationship to decline when a connective was present and for connectives to direct attention away from the details as processing attention was directed to the causal relationship. (c) I expected connective location to interact with clause order and differentiate reader strategies. The first two hypotheses were not supported. Instead, I found that as cohesion of the passage increased so did readers' confidence in the correct integration of the causal relationship and the incidental details embedded in those relationships. The third hypothesis regarding reading times was supported. Connective location interacted with clause order to differentiate processing. I turn to each of these findings in turn.

4.1 Integration and memory within causal relationships

The findings in this study are unable to support the elaboration hypothesis (Myers et al., 1987) or the continuity principle (Murray, 1997). Prior studies which can be used to support these hypotheses either found no effect or a deleterious effect on the ability to answer bridging inference questions when cohesion or causal relatedness was increased (Irwin, 1981; Maury & Teisserenc, 2005; McNamara et al., 1996; Myers et al., 1987; O'Reilly & McNamara, 2007; Ozuru et al.,

2008). Here, as cohesion increased, recognition memory improved. As stipulated in the introduction, such a finding does not argue against the elaboration hypothesis. Instead, the elaboration hypothesis may be true under some conditions but not the conditions of this study. Below I go through a few possible reasons for these diverging results.

First, as noted previously, many of the studies cited above used a small number of texts and participants answered comprehension questions about each text shortly after reading it. In our study, participants had to read 119 passages and wait at least 40 minutes before they could respond to a probe about the first critical passage. It is possible that memory is taxed by increasing the time between encoding and testing and increasing the variety of information that needs to be retained such that greater elaboration is no longer beneficial. Elaboration in the absence of a connective may include information that is not relevant to interpreting the relationship among the clauses that the author intended. At first, the additional elaboration may create a rich situation model form which the reader can base their interpretation (van Dijk & Kintsch, 1983). However, as the memory trace for a given passage breaks down, the existence of multiple elaborations stored along with the situation model may begin to interfere with each other. For example, if a reader considered that there may be relationships between several clauses, some of which were intended by the author and some not, then shortly after reading the passage, the reader may be able to sift through the more expansive situation model to find an interpretation that answers the question, but because they are stored together, as time passes and the trace decays, the elaborations blend and consolidate and what is left is only a partially correct situation model. Cohesive text may then better facilitate long term comprehension by constraining elaborations so that readers do not elaborate on more than is necessary to understand the intention of the author. When this happens,

there is less interference as the memory trace decays and the situation model can be recalled clearly.

Second, connectives may be unique among cohesive markers. Some of the studies on cohesion used very few connectives (e.g., McNamara et al., 1996; O'Reilly & McNamara, 2007). Further, when they were used, the answers to the comprehension questions did not necessarily require using the connective to join clauses. For example, McNamara et al. (1996) included sentence (6) in one of the texts and then the asked bridging inference question (7). The connective *because* is not necessary to make this association. The materials in this study were focused on the use of causal connectives and the questions designed specifically to probe memory for the clauses they joined. At no point could a reader have remembered only one clause and been able to correctly answer the bridging inference probe.

(6) This is because the rheumatic fever leaves scars in the valves of the heart.

(7) Which disease causes scarring of the heart?

As the studies showing the reverse cohesion effect do not test the effects of connectives directly, or possibly even tangentially, it is possible that connectives lead to a different type of processing than other cohesive devices. In this study, each connective resulted in a somewhat different effect on reading times, illustrating that readers use connectives as instructions on how to read and process clauses. However, this was not true for the other cohesive element used in the text, clause order. If a connective was not present in the sentence, readers did not show significant differences in how they processed information based on clause order. It is possible then that some cohesive devices are implicit and do not change readers' processing strategies, leading to more passive reading, but that connectives are unique in that they provide an explicit instruction which readers, at least in this study, follow to increase active reading.

Finally, it is possible that a confound in these texts or participants existed such that the texts were more difficult or required more domain knowledge than intended or the participants were highly skilled readers. Any of these confounds could result in higher comprehension in conditions containing a connective under the elaboration hypothesis. As I normed the stimuli to ensure the answers to the questions were clear from the passage, it is unlikely that the passages were too difficult for the population of readers sampled from. However, based on the SAT and ACT results reported, many of the participants were likely skilled readers. This may mean that one reason the inverse U of the elaboration hypothesis was not found here was because the readers, being skilled, were more likely to elaborate on the clauses regardless of the condition. Based on prior results, it seems unlikely that this alone could have resulted in the pattern of effects found here. Studies adding in measures of reading skill have not found that skilled readers benefit from high cohesion when they read an easier text or have higher domain knowledge but rather that that they show no differences (O'Reilly & McNamara, 2007; Ozuru et al., 2008) or if anything numerically decline (Linderholm et al., 2000). In this study, the more cohesive texts showed the highest outcomes for all participants which, even if the readers in the sample were skilled, still runs counter to previous findings.

Although the results suggest that potential confounds alone cannot account for the findings of this study, it is not clear if the increased time between the reading and testing phase or the focus on connectives is more likely to be responsible for the results. If a future study using these same materials but allowing participants to answer the questions immediately after reading the passage found the inverse U predicted by the elaboration hypothesis, this would support a theory that elaboration without cohesion is helpful in the short term but may increase interference with the memory trace over time. Further, follow up work using shorter sentences that only task

participants with remembering relationships presented within a text rather than relationships and details may also reduce the complexity of the texts. Finding the inverse U with the same manipulations but simpler text would suggest that in this experiment connectives were beneficial because they permitted comprehension to happen and that without the connective, comprehension failed because of text difficulty. Such an effect would be in line with the predictions of the elaboration hypothesis as elaboration will not help if comprehension fails (Myers et al., 1987). Finally, if the connectives uniquely facilitated memory for text then using connectives as a primary source of increasing cohesion in longer texts should result in the linear relationship between cohesion and connective presence found here.

The results of this study demonstrate that connectives can be beneficial to both processing and text comprehension. Further work is needed to understand the divide in the literature with some studies showing an advantage to connectives specifically (Maury & Teisserenc, 2005; Millis & Just, 1994; van Silfhout et al., 2015) and some showing that too much cohesion can be harmful to comprehension (e.g., McNamara et al., 1996). I tested the elaboration hypothesis (Myers et al., 1987) and continuity principle (Murray, 1997) to see if these theories could account for the differential results across studies. I was not able to find evidence supporting either of these theories. Instead, I found more support for the benefit of connectives in text. Additional work will need to be done to determine the precise circumstances in which connectives fail to help or even hurt comprehension.

4.2 What processing instructions do connectives provide?

There were several notable effects of reading processes. In general, there is evidence that readers changed their processing strategies, going so far as to delay processing in order to process clauses in forward causal structure. Further, when and where a reader received information about the location of cause within the sentence affected processing. Readers had greater difficulty when they found out they had just finished reading the cause after the fact than when they found out they had just finished reading the effect. Finally, when no connective was present, reading patterns did not reliably differ based on clause order suggesting that differences in reading patterns among connective interactions were related to the processing instructions provided by the connective.

The specifics of the findings noted in the results sections suggest that readers are especially attuned to causes. Regressions out showed greater regressions to a cause when a connective came in the middle and faster reading times of the effect when connectives came at the start of the sentence with longer reading times on the cause. Both results suggest readers went out of their way to pay close attention to the cause. However, the findings can also be taken more broadly to say that when connectives are present in a sentence, readers use the processing cues to trigger different strategies. The use of different reading strategies for each interaction between connectives and clause order suggests that readers took an active approach to reading passages containing connectives. They did not speed up processing in general just because it was easier to integrate the clauses when they knew how the content should be combined. Instead, they selectively sped up and slowed down processing and used regressions to fit the pattern of the text cued by the connective.

One of the critical findings in this paper involved the usage of the secondary connective *The reason*. This condition prompted greater regression out of the first noun phrase, and this may

reflect participants' attempts to link the clause they are reading back to the first sentence. However, I do not think that the expectation for presupposed information to come in the first clause drove the effects in the second clause nor decreased the reading times in the first clause. If this were a confounding factor, rather than faster reading times, I might expect slower reading time for the first clause following *The reason* as readers struggle to read clauses where they expect but are not given presupposed information. Further, by the time readers reach the second clause, they should expect new information just as in the other conditions. However, if *The reason* is instigating a pattern of results that are less related to the clause order and location of the connective and more related to the particulars of the phrase, it does not detract from the overall findings. Readers use connectives to change their reading strategy to a pattern that is most effective for the structure cued by the connective.

This finding recommends that further attention be paid to the location of a connective. As previously noted, very few studies have considered the differential effects of receiving a cue early in the sentence versus late. Considerations of these cues may inform our understanding of how readers both prefer to read text and how different strategies may affect comprehension. In particular, given that the readers in this sample likely skewed towards skilled, attention should be paid to whether these are patterns of highly skilled readers. van Silfhout et al. (2015) noted that the probability of a regression out was lower in general for skilled readers, but it maybe that in certain instances, such as a backward causal structure with a connective at the beginning or a forward causal structure with a connective in the middle, regression is strategic and the probability of regression out is actually higher for skilled readers. Such investigations can help further an understanding of what makes skilled readers skilled.

4.3 Conclusion

The effects found here support a view of online processing that is incremental (e.g., Traxler, Bybee, & Pickering, 1997) and one in which readers use strategies that will best facilitate processing according to the structure of the sentence. Further, when connectives were added to sentences and clauses were written with a forward causal structure, memory for both inferences and details improved. The effects here may mean that more elaboration is not better, but rather than elaboration must be targeted to only that which supports the intended meaning of the text. When elaboration is allowed to extend too far, memory for the text declines—at least if there is a significant delay before memory is probed and additional content is introduced in the interim. Further, although memory was not affected by the location of the connective, online reading processes were. This is an area that has received little attention but can provide details as to how and why readers change their reading strategies and potentially answer questions as to why certain clause structures are more common across languages than others (Stukker & Sanders, 2012). In all, the results of this study suggest that cohesive devices may have differential effects on processing and that when considering the effect cohesion has on active reading processes we need to look at both online reading strategies and offline comprehension in order to understand when and why cohesion may be helpful or harmful to comprehension.

Appendix A Additional Tables

Appendix Table 1 Fixed effects of reading for start of the verb phrase from a multilevel logit model of regressions out and multilevel models of log first pass, go past, and total time

	First Pass			Total Time			Regressions Out			Go Past		
	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	Wald *z*	*p*	$\hat{\beta}$	*t*	*p*
Intercept	6.79	123.03	<.001***	7.18	116.81	<.001***	-1.54	-5.72	<.001***	7.10	110.44	<.001***
Connective Presence	-0.06	-4.60	<.001***	-0.07	-5.28	<.001***	-0.13	-1.82	.07	-0.07	-4.92	<.001***
Connective Location	-0.01	-0.55	.58	-0.01	-0.75	.46	-0.01	-0.07	.94	-0.01	-0.67	.50
Clause Order	0.01	0.53	.60	0.02	1.24	.22	0.01	0.11	.91	0.01	0.51	.61
Sentence	0.02	1.74	0.08	0.09	7.14	<.001***	-0.05	-0.78	.44	0.02	1.56	.12

IA Length	0.06	19.80	<.001***	0.07	20.34	<.001***	0.02	1.28	.20	0.07	18.05	<.001***
Connective Presence x Clause Order	0.02	0.77	.44	0.05	1.89	.06	0.05	0.35	.73	0.05	1.85	.07
Connective Location x Clause Order	-0.01	-0.48	.63	-0.02	-0.56	.57	-0.12	-0.71	.48	-0.05	-1.34	.18
Connective Presence x Sentence	0.06	2.60	.009 **	0.07	2.65	.008	-0.01	-0.04	.97	0.04	1.39	.17
Connective Location x Sentence	0.004	0.14	.89	-0.05	-1.49	.14	0.43	-2.50	.01	-0.08	-2.32	.02
Sentence x Clause Order	0.08	3.26	<.001***	0.07	2.66	.008	0.20	1.37	.17	0.09	3.11	.002
Connective Presence x	0.05	1.05	.29	0.01	0.17	.87	0.10	0.33	.74	0.001	0.02	.98

Sentence x Clause Order												
Connective Location x Sentence x Clause Order	0.02	0.41	.68	0.12	1.93	.05	0.54	1.54	.12	0.10	1.43	.15

Appendix Table 2 Fixed effects of reading for the whole clause from a multilevel logit model of regressions out and multilevel models of log first pass, go past, and total time

	First Pass			Total Time			Regressions Out			Go Past		
	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	Wald *z*	*p*	$\hat{\beta}$	*t*	*p*
Intercept	7.70	215.23	<.001***	7.97	207.75	<.001***	0.62	5.52	<.001***	8.00	208.22	<.001***
Connective Presence	-0.04	-4.88	<.001***	-0.03	-3.95	<.001***	-0.18	-2.41	.02	-0.05	-4.97	<.001***
Connective Location	-0.03	-3.44	<.001***	0.03	2.84	.005	-0.005	-0.06	.95	-0.03	-2.83	.005
Clause Order	0.03	3.56	<.001***	0.02	2.95	.003	0.06	0.85	.39	0.02	2.33	.02 *
Sentence	0.08	10.31	<.001***	0.11	13.76	<.001***	0.04	-0.55	.58	0.09	9.61	<.001***
Connective Presence x Clause Order	0.03	2.10	.04 *	0.04	2.24	.03	-0.17	-1.14	.26	0.05	2.39	.02 *
Connective Location x Clause Order	-0.03	-1.56	.12	-0.04	-1.81	.07	-0.53	-3.22	.001	-0.03	-1.46	.14

Connective Presence x Sentence	0.06	3.61	<.001***	0.05	2.75	.006	-0.51	-3.51	<.001***	0.007	0.38	.70
Connective Location x Sentence	-0.07	-4.06	<.001***	-0.09	-4.33	<.001***	0.20	-1.24	.21	-0.07	-3.28	.001 **
Sentence x Clause Order	-0.01	0.33	.74	0.07	4.00	<.001***	0.07	0.48	.63	0.07	4.05	<.001***
Connective Presence x Sentence x Clause Order	0.02	0.55	.58	-0.07	-2.12	.03	-0.23	-0.78	.43	-0.13	-3.46	<.001***
Connective Location x Sentence x Clause Order	0.02	0.41	.68	0.06	1.60	.11	0.47	1.42	.15	0.07	1.63	.10

Appendix Table 3 Fixed effects of reading for the end of the clauses from a multilevel logit model of regressions out and multilevel models of log first pass, go past, and total time

	First Pass			Total Time			Regressions Out			Go Past		
	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	*t*	*p*	$\hat{\beta}$	Wald *z*	*p*	$\hat{\beta}$	*t*	*p*
Intercept	6.38	148.18	<.001***	6.66	136.65	<.001***	-0.95	-4.88	<.001***	6.72	121.33	<.001***
Connective Presence	-0.04	1.95	.05 .	0.03	2.07	.04 *	-0.38	-5.99	<.001***	-0.06	-3.50	<.001***
Connective Location	-0.04	-2.71	.007**	-0.02	-1.29	.20	-0.03	-0.44	.66	-0.04	-2.17	.03 *
Clause Order	-0.03	-1.74	.09 .	-0.03	-1.61	.11	0.09	1.52	.13	-0.02	-1.06	.29
Sentence	0.06	5.10	<.001***	0.10	7.76	<.001***	-0.25	-4.07	<.001***	0.08	0.50	.62
IA Length	0.05	20.64	<.001***	0.05	20.97	<.001***	0.02	1.79	.07 .	0.05	15.40	<.001***
Connective Presence x Clause Order	0.01	0.33	.74	-0.01	-0.46	.65	0.17	1.32	.19	0.06	1.71	.09 .

Connective Location x Clause Order	0.01	0.29	.77	-0.04	-1.33	.18	0.03	0.20	.84	0.02	0.54	.59
Connective Presence x Sentence	0.04	1.69	.09 .	0.11	4.26	<.001***	0.48	-3.75	<.001***	-0.04	-1.32	.19
Connective Location x Sentence	-0.02	-0.82	.41	-0.02	-0.77	.44	-0.15	-0.99	.32	-0.03	-0.72	.47
Sentence x Clause Order	-0.01	-0.60	.55	0.01	0.20	.84	0.53	4.21	<.001***	0.12	3.71	<.001***
Connective Presence x Sentence x Clause Order	0.02	-0.34	.74	-0.10	-1.81	.07 .	0.10	0.40	.69	-0.09	-1.37	.17
Connective Location x Sentence x Clause Order	0.02	-0.38	.70	0.11	-1.83	.07 .	-0.15	-0.48	.63	0.08	-1.03	.31

Appendix B Stimuli

Appendix Table 4 Comprehension probes asked during reading task

Comprehension Question	Correct answer	Included in analysis
1. Did the cave paintings depict a man hunting a boar?	no	Responses not recorded
2. Did the Pirates play the Red Sox during the first World Series?	yes	Used
3. Did Amenemhat build the Black Pyramid?	yes	Used
4. Was John F. Kennedy the youngest person to serve as President of the United States?	no	Not Used
5. Have you read about Fairy Tales?	yes	Used
6. Have you read about Neil Armstrong?	no	Used
7. Were the people of the Grave Creek Mound a mining people?	no	Used
8. Did the Song Dynasty invent the compass?	yes	Used
9. Have your read anything about archaeologists yet?	yes	Not Used
10. Did Mexico have a recent political scandal involving voter fraud?	no	Used

11. Might brown bananas help destroy cancer cells?	yes	Used

Appendix Table 5 Practice materials

Practice Passage	Correct Inference	Incorrect Inference	Detail Question
The 21st century saw a number of innovations in luggage production. Luggage manufactures started to produce luggage out of a plastic material to increase its durability because baggage handlers flip luggage onto its front side to avoid damaging conveyor belts with the wheels. New luggage usually comes with four wheels instead of two.	The way baggage handlers treat luggage has resulted in an increased demand for more durable luggage.	New advances in hard luggage production prompted a change in airport policy aimed at protecting their conveyor belts.	What material was used to make more durable luggage in the earlier passage? Plastic Metal
Febreze originally got rid of foul odors without adding any pleasant scents. Removing odors did not encourage focus groups to use the product on a regular basis. Pleasant scents were added to the mix by engineers working on the product. Febreze is now one of Proctor and Gamble's best-selling products.	Febreze wasn't well received at first because it only masked foul odors; it didn't actually eliminate foul odors.	In order to make the use of Febreze a habit, the product needed to do more than remove foul odors; it needed to add pleasant ones.	Who added scents to the new Febreze product? Engineers Inventors

Appendix Table 6 Complete stimuli list. Bolded answers are correct choices for memory probes

	Effect – Cause Ordering	Cause – Effect Ordering	Inference Question and Answers	Detail Question and Answers	
1	Andy Warhol had rheumatic fever as a child. [The reason] Warhol's heart was restricted in its ability to pump oxygen through his lungs later in life. [is - because] The fever left scars on the valves of his heart at an early age. Warhol died as an adult from a dysregulated heartbeat after a routine surgery.	Andy Warhol had rheumatic fever as a child. [Because] The fever left scars on the valves of his heart at an early age. [, so] Warhol's heart was restricted in its ability to pump oxygen through his lungs later in life. Warhol died as an adult from a dysregulated heartbeat after a routine surgery.	Based on the passage about Andy Warhol, it is most reasonable to conclude …	What part of Andy Warhol's body did his heart have trouble pumping enough oxygen to?	
			Scars from a fever restricted the ability of Andy Warhol's heart to pump oxygen through his body.	**lungs**	brain
			Andy Warhol acquired scar tissue on his heart from the prolonged struggle of his heart to pump oxygen through his body.		
2	The smallest species of frog in the world lives in Papua New Guinea. [The reason] Field researchers discovered the tiny frogs with yellow stripes on their back only recently. [is - because] The frog's call resembles the sound of an insect in the dense forests. They have garnered interest	The smallest species of frog in the world lives in Papua New Guinea. [Because] The frog's call resembles the sound of an insect in the dense forests. [, so] Field researchers discovered the tiny frogs with yellow stripes on their back only recently. They have garnered interest from the	Based on the passage about the world's smallest frog, it is most reasonable to conclude …	What do the world's tiniest frogs have on their backs?	
			The tiniest frog in the word went undiscovered because biologists walking through its habitat thought for years that	**stripes**	spots

	from the scientific community in recent years.	scientific community in recent years.	**its calls were just the sound of insects.**		
			The world's smallest frog replicates the sound of insects in order to camouflage its presence from predators.		
3	Animal behaviorists recently found that dogs are attuned to human emotion. [The reason] The dogs displayed behaviors most commonly associated with the experience of stress. [is - because] The behaviorists exposed the dogs at a lab in Toronto to human fear pheromones. It brings truth to the rumor that animals can smell fear.	Animal behaviorists recently found that dogs are attuned to human emotion. [Because] The behaviorists exposed the dogs at a lab in Toronto to human fear pheromones. [, so] The dogs displayed behaviors most commonly associated with the experience of stress. It brings truth to the rumor that animals can smell fear.	Based on the passage about fear pheromones, it is most reasonable to conclude …	Where were dogs exposed to vials filled with human fear pheromones?	
			The smell of human fear caused dogs in a laboratory study to become stressed.	**Toronto**	Tokyo
			Animal behaviorists have discovered that stressed dogs can elicit fear pheromones from humans.		

4	The Jeju dog was brought back from the edge of extinction in Korea. [The reason] The Koreans built a monument in white marble to honor the Jeju as a heritage animal. [is - because] The Japanese ordered the slaughter of dogs indigenous to Korea during one of their military occupations. Many Koreans covet a Jeju as a pet.	The Jeju dog was brought back from the edge of extinction in Korea. [Because] The Japanese ordered the slaughter of dogs indigenous to Korea during one of their military occupations. [, so] The Koreans built a monument in white marble to honor the Jeju as a heritage animal. Many Koreans covet a Jeju as a pet.	Based on the passage about the Jeju dog, it is most reasonable to conclude …	What is the monument to the Jeju dog in Korea made out of?	
			The Jeju dog was given the designation of heritage animal by the Koreans because the dog was targeted by the Japanese during their occupation.	**marble**	granite
			The Japanese targeted the Jeju dog during their occupation of Korea because the animal was a Korean heritage symbol.		
5	Early organization of law in colonial societies faced many setbacks. [The reason] The colonists did not participate on councils with the magistrates to develop laws. [is - because] The people no longer wanted to be associated with their old countries. The colonies were split as how best to handle the question of justice.	Early organization of law in colonial societies faced many setbacks. [Because] The people no longer wanted to be associated with their old countries. [, so] The colonists did not participate on councils with the magistrates to develop laws. The colonies were split as how best to handle the question of justice.	Based on the passage about early colonial laws, it is most reasonable to conclude …	What did the people of the colonies refuse to participate on?	
			The people in the early colonies of America did not want to participate in making the laws for their new colony because they did not want to be connected to their old countries.	councils	courts

			The people in the early colonies of America did not want to be connected to their old countries because those countries had not included them in the creation of the laws they were expected to follow.		
6	Stalkers will explore all avenues to discover private information about their victims. [The reason] The Privacy Act was passed to limit the disclosure of personal information by government institutions. [is - because] John Bardo obtained the address of a murder victim he stalked for several weekends through the DMV. Bardo is currently serving a life sentence in maximum security.	Stalkers will explore all avenues to discover private information about their victims. [Because] John Bardo obtained the address of a murder victim he stalked for several weekends through the DMV. [, so] The Privacy Act was passed to limit the disclosure of personal information by government institutions. Bardo is currently serving a life sentence in maximum security.	Based on the passage about the stalker, John Bardo, it is most reasonable to conclude …	When did John Bardo stalk his victim?	
			The Privacy Act was enacted because it was discovered that a woman's address was released to her stalker by the DMV.	**weekends**	evenings
			John Bardo's arrest was made possible by the Privacy Act, which made obtaining private information through the DMV illegal.		

7	Quechuan farming practices in the Andes offer a lesson to industrial farmers. [The reason] Future generations will be able to grow wheat in environments changed by global warming. [is - because] Quechuan farmers needed to adapt crops to the extraordinary range of climatic diversity in the Andes. The Quechuan methods can be mimicked in more temperate regions.	Quechuan farming practices in the Andes offer a lesson to industrial farmers. [Because] Quechuan farmers needed to adapt crops to the extraordinary range of climatic diversity in the Andes. [, so] Future generations will be able to grow wheat in environments changed by global warming. The Quechuan methods can be mimicked in more temperate regions.	Based on the passage about Andean potato farming, it is most reasonable to conclude …	What product have the Quechuan people adapted to diverse environments?	
			The crops grown in the Andes are diverse from having developed in multiple environments, so as the world's climate changes, those crops will still be a viable food source.	wheat	potatoes
			The Quechuan people have adapted the potato to diverse environments because they wanted to safeguard crops against the damaging effects of climate change.		
8	One indicator used to judge living conditions in Allegheny County is air quality. [The reason] The county has been unable to move up in rankings of livability for several years.	One indicator used to judge living conditions in Allegheny County is air quality. [Because] Allegheny County has a large amount of particle pollution from aluminum	Based on the passage about Allegheny County, it is most reasonable to conclude …	What type of industry produces pollution in Allegheny County?	

	[is - because] Allegheny County has a large amount of particle pollution from aluminum production in its outer regions. Ecologists insist action must be taken to preserve living conditions.	production in its outer regions. [, so] The county has been unable to move up in rankings of livability for several years. Ecologists insist action must be taken to preserve living conditions.	**Livability rankings for Allegheny County are held back by the effect of industrial activity on the county's air quality.**	aluminum	plastic
			Because of the high rates of industrial activity in Allegheny County, environmentalists are taking action to improve living conditions.		
9	The success of the Romans depended on more than their military fortitude. [The reason] Few Romans died from diseases associated with the consumption of parasites in water. [is - because] The Romans built sewage systems to keep drinking water separated from waste runoff. The technology had the advantage of keeping Roman soldiers fit during long campaigns.	The success of the Romans depended on more than their military fortitude. [Because] The Romans built sewage systems to keep drinking water separated from waste runoff. [, so] Few Romans died from diseases associated with the consumption of parasites in water. The technology had the advantage of keeping Roman soldiers fit during long campaigns.	Based on the passage about the Romans, it is most reasonable to conclude …	What did the Roman sewage system manage to keep out of the drinking water?	
			Romans didn't suffer from certain illnesses as often as previous generations because they had access to cleaner water.	parasites	bacteria
			The health and longevity of the Roman people made it possible to maintain a large society capable of building complex structures, like sewage systems.		

10	The pangolin is a type of nocturnal anteater. [The reason] The pangolin is trafficked at steep prices more than any other mammal in the world. [is - because] Medicinal qualities are attributed to the scales of the animal for use against various diseases. A pangolin specialist group has arisen to combat this issue in Asia and Africa.	The pangolin is a type of nocturnal anteater. [Because] Medicinal qualities are attributed to the scales of the animal for use against various diseases. [, so] The pangolin is trafficked at steep prices more than any other mammal in the world. A pangolin specialist group has arisen to combat this issue in Asia and Africa.	Based on the passage about the pangolin anteater, it is most reasonable to conclude …	What part of the pangolin is consumed for medical purposes?	
			People's beliefs that the pangolin anteater can cure diseases has led to illegal trafficking and sales of the animal.	scales	organs
			Animal traffickers created a story about the healing qualities of the pangolin anteater in order to sell it for high prices.		
11	Small farms are becoming a business of the past. [The reason] Their farmland is being used in Indiana as space for solar panel power plants. [is - because] Many farmers are having a difficult time making enough money off corn sales to stay solvent. Farming production in the state is at an all-time low.	Small farms are becoming a business of the past. [Because] Many farmers are having a difficult time making enough money off corn sales to stay solvent. [, so] Their farmland is being used in Indiana as space for solar panel power plants. Farming production in the state is at an all-time low.	Based on the passage about farmland being used for solar panels, it is most reasonable to conclude …	In what state are solar panel stations being placed on farmland?	
			The decline in income from crop sales has led some farmers to lease out their land to solar power companies.	Indiana	Nebraska
			The profit from leasing out farmland to solar power companies is driving a reduction in crop production.		

12	On August 13, 1964, Kitty Genovese was stabbed, sexually assaulted, and murdered in Queens. [The reason] Thirty-eight witnesses did not call the police for help on the morning of Genovese's murder. [is - because] People in groups tend to assume someone else will take responsibility even in emergency situations. The murder stimulated social psychological research into the bystander effect.	On August 13, 1964, Kitty Genovese was stabbed, sexually assaulted, and murdered in Queens. [Because] People in groups tend to assume someone else will take responsibility even in emergency situations. [, so] Thirty-eight witnesses did not call the police for help on the morning of Genovese's murder. The murder stimulated social psychological research into the bystander effect.	Based on the passage about the murder of Genovese, it is most reasonable to conclude …	What time of day was Genovese stabbed?	
			No one called the police during Genovese's murder because everyone assumed someone else had already called the police.	morning	night
			During the murder of Genovese, had someone called the police, her life would have been saved.		
13	Death Valley in California contains sections of rock covered in pictographs made by prehistoric civilizations. [The reason] The rock walls contain unmarred images of	Death Valley in California contains sections of rock covered in pictographs made by prehistoric civilizations. [Because] Indigenous populations have long deemed	Based on the passage about Death Valley, it is most reasonable to conclude …	What does the topography near the pictographs in Death Valley consist of?	

	ancient rituals in the region. [is - because] Indigenous populations have long deemed the valley near the badlands to be uninhabitable. The pictographs are under threat from the increased development happening in the valley today.	the valley near the badlands to be uninhabitable. [, so] The rock walls contain unmarred images of ancient rituals in the region. The pictographs are under threat from the increased development happening in the valley today.	**The absence of human settlement in Death Valley has kept pictographs on cliff walls in the region safe from destruction through human interaction.** Indigenous people in Death Valley are striving to protect the sacred images on the rock walls.	badlands	dunes
14	Drug dealers surprisingly do report and pay taxes on their income. [The reason] The federal government is unlikely to legalize drugs in the near future. [is - because] Legalized drug businesses could take tax deductions in excess of five billion dollars. Drug laws often have little to do with the dangers of the drug itself.	Drug dealers surprisingly do report and pay taxes on their income. [Because] Legalized drug businesses could take tax deductions in excess of five billion dollars. [, so] The federal government is unlikely to legalize drugs in the near future. Drug laws often have little to do with the dangers of the drug itself.	Based on the passage about the legalization of drugs, it is most reasonable to conclude …	How many billions of dollars would be lost to tax deductions if drugs were legalized?	
			Legalizing drugs would reduce income taxes, so the government has little incentive to legalize them. If Congress legalizes drugs in the future it will be because they need to collect the money from the sales tax.	five	ten

15	Auroras are awe-inspiring waves of color illuminated in the sky. [The reason] Many tourists choose to fly in the spring months to Alaska. [is - because] The Alaskan state is listed in travel magazines for its beautiful auroras. The lights are believed to have an electrical origin in the upper atmosphere.	Auroras are awe-inspiring waves of color illuminated in the sky. [Because] The Alaskan state is listed in travel magazines for its beautiful auroras. [, so] Many tourists choose to fly in the spring months to Alaska. The lights are believed to have an electrical origin in the upper atmosphere.	Based on the passage about auroras, it is most reasonable to conclude …	When do many tourists visit Alaska to see the auroras?	
			Alaska is a popular tourist destination because of its reputation in travel magazines for beautiful auroras.	spring	summer
			Tourism magazines started recommending Alaska as a tourist destination after reports from tourists about its beautiful auroras.		
16	Leafcutter ants maintain mushroom farms in humid environments. [The reason] The mushrooms thrive without suffering from diseases brought on by bacteria living in the area. [is - because] The ants cover the mushrooms with a compound produced in their saliva from chewing plants. The flourishing of the mushroom gardens is critical for the ant colony's survival.	Leafcutter ants maintain mushroom farms in humid environments. [Because] The ants cover the mushrooms with a compound produced in their saliva from chewing plants. [, so] The mushrooms thrive without suffering from diseases brought on by bacteria living in the area. The flourishing of the mushroom gardens is critical for the ant colony's survival.	Based on the passage about leafcutter ants, it is most reasonable to conclude …	Where do leafcutter ants produce the compound that protects the mushrooms?	
			Leafcutter ants cover the mushrooms in their farms with a compound because the compound keeps the mushrooms free from many diseases.	saliva	glands

			Compounds in the mushrooms, consumed while eating them, help ensure that the leafcutter ant colony stays free from disease.		
17	The Internet has become fascinated with a microscopic animal called a tardigrade. [The reason] The species is believed to have enough genetic diversity to survive a future extinction event. [is - because] The creatures have been found alive following decimation by wildfires of jungle regions. The genetic variety can make classifying the tardigrade difficult for taxonomists.	The Internet has become fascinated with a microscopic animal called a tardigrade. [Because] The creatures have been found alive following decimation by wildfires of jungle regions. [, so] The species is believed to have enough genetic diversity to survive a future extinction event. The genetic variety can make classifying the tardigrade difficult for taxonomists.	Based on the passage about tardigrades, it is most reasonable to conclude …	What natural disaster have tardigrades been known to survive?	
			The ability of the tardigrade to survive environmental disasters has led to the speculation that the animal could survive a large-scale extinction event.	**wildfires**	volcanos
			Because the tardigrade has survived several large scale extinction events, it has adapted to a diverse array of extreme environments.		

18	Citalopram is an antidepressant of the selective serotonin reuptake inhibitor class. [The reason] The drug was reported by independent reviewers in Sweden to be among the safest in its class. [is - because] Other drugs have a low probability of interacting with Citalopram to produce unwanted side effects. Depression typically subsides within two weeks from the first dose.	Citalopram is an antidepressant of the selective serotonin reuptake inhibitor class. [Because] Other drugs have a low probability of interacting with Citalopram to produce unwanted side effects. [, so] The drug was reported by independent reviewers in Sweden to be among the safest in its class. Depression typically subsides within two weeks from the first dose.	Based on the passage about the antidepressant, Citalopram, it is most reasonable to conclude …	Where are the reviewers who concluded Citalopram is a safe drug from?	
			The low probability of Citalopram interacting with other drugs gives scientists confidence that the drug is safe for human use.	**Sweden**	Denmark
			Scientists rated Citalopram highly because it can reduce depression symptoms quickly as compared to other antidepressants.		
19	Hot air balloons are a popular way to capture an aerial view of the Earth. [The reason] Even experienced pilots can have difficulty piloting the balloons safely some of the time. [is - because] Wind gusts can change direction dramatically with small changes in the altitude of the atmosphere. Balloons have	Hot air balloons are a popular way to capture an aerial view of the Earth. [Because] Wind gusts can change direction dramatically with small changes in the altitude of the atmosphere. [, so] Even experienced pilots can have difficulty piloting the balloons safely some of the time. Balloons have collided with	Based on the passage about hot air balloons, it is most reasonable to conclude …	What type of changes do hot air balloon pilots have to be aware can change the direction of the wind?	
			Hot air balloons are difficult to pilot because the amount of wind driving it can change suddenly.	**altitude**	pressure

	collided with tall buildings in cities like Chicago.	tall buildings in cities like Chicago.	Hot air balloons are dangerous to pilot in cities because of the wind tunnels created by the tall buildings.		
20	Alexander the Great subjugated Egypt under Greek rule. [The reason] A Greek Pharaoh established a god of wisdom with a Greek appearance and Egyptian clothes. [is - because] The Egyptians needed to be united with the Greeks in the years following Alexander's conquest. Worship of the god Serapis continued for another 600 years.	Alexander the Great subjugated Egypt under Greek rule. [Because] The Egyptians needed to be united with the Greeks in the years following Alexander's conquest. [, so] A Greek Pharaoh established a god of wisdom with a Greek appearance and Egyptian clothes. Worship of the god Serapis continued for another 600 years.	Based on the passage about the Greek conquest in Egypt, it is most reasonable to conclude …	What was the Greek-Egyptian hybrid god in charge of?	
			Establishing a god with both Greek and Egyptian features helped merge the two cultures.	**wisdom**	harvest
			The Egyptian god Serapis obtained a more Greek-like physical appearance because the Greeks appropriated him during their time as rulers of Egypt.		
21	The Vietnam War left the surrounding countries with fields filled with land mines. [The reason] Mine clearance is being executed by the United	The Vietnam War left the surrounding countries with fields filled with land mines. [Because] The mines have been responsible in Cambodia	Based on the passage about land mines, it is most reasonable to conclude …	What has been lost in large numbers to land mines?	

	Nations as a humanitarian effort. [is - because] The mines have been responsible in Cambodia for lost buffalo and over 60,000 civilian deaths. The use of mines as a military weapon continues today.	for lost buffalo and over 60,000 civilian deaths. [, so] Mine clearance is being executed by the United Nations as a humanitarian effort. The use of mines as a military weapon continues today.	**High rates of civilian death prompted the United Nations to clear land mines left behind after the Vietnam War.**	**buffalo**	sheep
			During humanitarian efforts to clear mine fields, many people have died by accidentally tripping the mines.		
22	The Battle of the Alamo was followed by a second, lesser known massacre of the Texan army. [The reason] The Mexican army encircled the Texan troops with a substantial cavalry force. [is - because] The retreating Texans made frequent stops for their oxen to graze in open plains. The battle took more Texan lives than that of the Alamo.	The Battle of the Alamo was followed by a second, lesser known massacre of the Texan army. [Because] The retreating Texans made frequent stops for their oxen to graze in open plains. [, so] The Mexican army encircled the Texan troops with a substantial cavalry force. The battle took more Texan lives than that of the Alamo.	Based on the passage about the aftermath of the Alamo, it is most reasonable to conclude …	During the aftermath of the Alamo, what did the Texas army stop at the clearing to feed?	
			The Texan army's decision to stop to allow their animals to graze during their retreat allowed the Mexican army to catch up to and slaughter the Texan troops.	**oxen**	horses
			The Texan army had to stop during their retreat in order to rally their forces because the Mexican army was rapidly gaining on them.		

23	Murasaki Shikibu, a woman, wrote the first novel in the 11th century. [The reason] The novel centers on the numerous love affairs happening in the Imperial palaces of Tokyo. [is - because] Murasaki Shikibu served at court for a royal woman with a love for archaic grammar in poetry. The Tale of Genji has been translated into numerous languages.	Murasaki Shikibu, a woman, wrote the first novel in the 11th century. [Because] Murasaki Shikibu served at court for a royal woman with a love for archaic grammar in poetry. [, so] The novel centers on the numerous love affairs happening in the Imperial palaces of Tokyo. The Tale of Genji has been translated into numerous languages.	Based on the passage about the Tale of Genji, it is most reasonable to conclude …	What type of writing did the noblewoman who Murasaki Shikibu served enjoy?	
			Murasaki Shikibu wrote her novel about what she witnessed as a courtier for the royal court and that was sexual scandal and intrigue.	**obscure grammar**	obscure vocabulary
			Murasaki Shikibu was asked to become a courtier at the Japanese royal court because a noblewoman enjoyed her stories about sexual scandal and intrigue.		
24	The USS Maine sank on March 28, 1888, in the Caribbean Sea. [The reason] A war broke out along cotton trade routes between the Spanish and American governments. [is - because] American authorities believed an underwater mine set off the explosion responsible for capsizing the naval ship. The	The USS Maine sank on March 28, 1888, in the Caribbean Sea. [Because] American authorities believed an underwater mine set off the explosion responsible for capsizing the naval ship. [, so] A war broke out along cotton trade routes between the Spanish and American governments. The war ended in just four short months.	Based on the passage about the USS Maine, it is most reasonable to conclude …	How did the USS Maine sink?	
			The United States started the Spanish-American War because they blamed Spain for sinking the USS Maine.	**it capsized**	a hull breach

	war ended in just four short months.		The Spanish sunk the USS Maine because the naval ship was disrupting critical trade routes during the Spanish-American war.		
25	The three goddesses accepted as the Fates were the personification of destiny. [The reason] Greek parents laid sacrifices on maple wood altars at shrines to the Fates. [is - because] The Fates had the power to determine the future of the recently born. The three Fates were ever present in the lives of the ancient Greeks.	The three goddesses accepted as the Fates were the personification of destiny. [Because] The Fates had the power to determine the future of the recently born. [, so] Greek parents laid sacrifices on maple wood altars at shrines to the Fates. The three Fates were ever present in the lives of the ancient Greeks.	Based on the passage about the three Fates, it is most reasonable to conclude …	Where did parents go to make sacrifices to the Three Fates?	
			Parents made offerings to the Fates in the hopes that their children would be blessed with a good life.	**shrines**	temples
			Parents made offerings to the Fates out of gratitude for blessing their lives with children.		
26	The northern hairy-nosed wombat lives underground in a network of burrows. [The reason] The wombats avoid emerging above ground into the harsh winds typical of their	The northern hairy-nosed wombat lives underground in a network of burrows. [Because] The tunnels stay at a climate ideal to the comfort of the animal. [, so] The wombats	Based on the passage about the northern hairy-nosed wombat, it is most reasonable to conclude …	What does the northern hairy-nosed wombat avoid by staying in its burrow?	

	habitat. [is - because] The tunnels stay at a climate ideal to the comfort of the animal. Young are usually born during the wet season between November and April.	avoid emerging above ground into the harsh winds typical of their habitat. Young are usually born during the wet season between November and April.	**The wombat does not come above ground very often because the temperature in its burrows is more comfortable than the outdoors.** The wombat gives birth to its young inside burrows because the temperatures above ground are not safe for the newborns.	**wind**	sun
27	The sinking of the Estonia cruise ship in 1994 shocked the world. [The reason] The passengers on board could not reach the lifeboats on the starboard side of the ship. [is - because] The ship took on a steep list at night from water flooding the bow. Nearly one thousand people drowned during the sinking of the Estonia.	The sinking of the Estonia cruise ship in 1994 shocked the world. [Because] The ship took on a steep list at night from water flooding the bow. [, so] The passengers on board could not reach the lifeboats on the starboard side of the ship. Nearly one thousand people drowned during the sinking of the Estonia.	Based on the passage about the sinking of the Estonia cruise ship, it is most reasonable to conclude …	When the Estonia sunk, what side of the ship were the lifeboats on?	
			The passengers of the capsizing Estonia were unable to make it to the lifeboats because of the steep list of the boat. The rush of passengers to the lifeboats on one side of the ship caused the ship's list to steepen, hastening the rate at which it capsized.	**starboard**	port

28	One of the most dangerous substances for pregnant women to consume is alcohol. [The reason] Alcohol exposure can result in major neurological damage to the hippocampus of the fetal brain. [is - because] The human fetus has a particularly underdeveloped set of organs for breaking down alcohol. Pregnant alcoholics should seek support to ensure they do not relapse.	One of the most dangerous substances for pregnant women to consume is alcohol. [Because] The human fetus has a particularly underdeveloped set of organs for breaking down alcohol. [, so] Alcohol exposure can result in major neurological damage to the hippocampus of the fetal brain. Pregnant alcoholics should seek support to ensure they do not relapse.	Based on the passage about alcohol during pregnancy, it is most reasonable to conclude …	What region of the brain does alcohol affect in unborn babies?	
			The inability of fetal organs to break down alcohol can result in neurological damage.	**hippocampus**	hypothalamus
			Damage to the fetus's brain from alcohol can result in poor functioning and development of the fetal organs.		
29	On the Antiques Road Show, people would bring antiques from their home for appraisal on live TV. [The reason] The show's appraisers sometimes lied about the rarity of objects brought in by their friends. [is - because] The items featured often sold within hours for prices inflated beyond their market value. Netflix has expressed interest in rebooting the show.	On the Antiques Road Show, people would bring antiques from their home for appraisal on live TV. [Because] The items featured often sold within hours for prices inflated beyond their market value. [, so] The show's appraisers sometimes lied about the rarity of objects brought in by their friends. Netflix has expressed interest in rebooting the show.	Based on the passage about the Antiques Road Show, it is most reasonable to conclude …	What did appraisers lie about with regards to the antiques brought in by their friends?	
			The appraisers on the Antiques Road Show lied to viewers in order to sell ordinary objects for high prices.	**rarity**	quality

			The Antiques Road Show went off the air when it became clear that the appraisers were lying about the value of objects.		
30	The lipstick plant is prized for its lipstick tube-like flower buds. [The reason] Plant enthusiasts place lipstick plants in gardens in the hopes of creating interesting aesthetics. [is - because] The plant grows on the surface of other organisms without needing nutrients from them. The flowers can be found in the wild all across Asia.	The lipstick plant is prized for its lipstick tube-like flower buds. [Because] The plant grows on the surface of other organisms without needing nutrients from them. [, so] Plant enthusiasts place lipstick plants in gardens in the hopes of creating interesting aesthetics. The flowers can be found in the wild all across Asia.	Based on the passage about lipstick plants, it is most reasonable to conclude …	What don't lipstick plants need much of in order to grow?	
			Plant enthusiasts enjoy the aesthetics of lipstick plants because the plants can grow on a host plant.	**nutrients**	light
			Plant enthusiasts enjoy the aesthetic of lipstick plants, but they must take care that the plant does not grow onto nearby plants.		
31	Sigmund Freud was almost another Jewish person lost to the Nazis during WWII. [The reason] Freud's friends were able to convince him to flee	Sigmund Freud was almost another Jewish person lost to the Nazis during WWII. [Because] His daughter was aggressively interrogated for	Based on the passage about Sigmund Freud, it is most reasonable to conclude …	When was Sigmund Freud's daughter interrogated?	

	Austria in October for England. [is - because] His daughter was aggressively interrogated for three days early during the war. Had he stayed, he likely would have been arrested and killed.	three days early during the war. [, so] Freud's friends were able to convince him to flee Austria in October for England. Had he stayed, he likely would have been arrested and killed.	**Freud realized he needed to flee Austria to escape the Nazis after his daughter was interrogated.** After Freud fled Austria, his daughter was interrogated by the Nazis.	**October**	March
32	Soil erosion is a growing concern among agricultural scientists. [The reason] Soil erosion will replace petroleum scarcity as the nation's most critical natural resource problem. [is - because] Heavy demands continue to be placed on farmland by soybean production in the Midwest. The problem will continue to grow with the expansion of the population.	Soil erosion is a growing concern among agricultural scientists. [Because] Heavy demands continue to be placed on farmland by soybean production in the Midwest. [, so] Soil erosion will replace petroleum scarcity as the nation's most critical natural resource problem. The problem will continue to grow with the expansion of the population.	Based on the passage about soil erosion in the United States, it is most reasonable to conclude …	What produce is placing heavy demands on the soil in the Midwest?	
			The demands placed on the farmland of the Midwest will erode the soil, turning crop production into one the most critical resource problems in the country. Soil erosion in some parts of the United States is increasing the burden of crop production in the Midwest.	**soybean**	corn

33	Dadaism is an art movement that developed in response to the senselessness of WWI. [The reason] The Dada poets used language absurdly with nonsense vocabulary meant to break with traditional form. [is - because] The Dadaists saw intellectual conformity as the Imperialist mission at the heart of the war. Many of the Dada artists evolved into Surrealists.	Dadaism is an art movement that developed in response to the senselessness of WWI. [Because] The Dadaists saw intellectual conformity as the Imperialist mission at the heart of the war. [, so] The Dada poets used language absurdly with nonsense vocabulary meant to break with traditional form. Many of the Dada artists evolved into Surrealists.	Based on the passage about Dadaism, it is most reasonable to conclude …	What type of mission did the Dadaists believe was at the heart of the first World War?	
			According to Dadaism, breaking down language into nonsense syllables frees it from conformity with the past.	**Imperialist**	Capitalist
			Because many of the Dadaists became surrealists, surrealism retains many of the absurd elements of Dadaism.		
34	Korean babies are considered to be one year old upon birth. [The reason] Korean children can differ in age by as much as two years from their American counterparts. [is - because] The second birthday is celebrated during the waxing of the first moon each lunar year. All Koreans born in the same year are effectively the same age.	Korean babies are considered to be one year old upon birth. [Because] The second birthday is celebrated during the waxing of the first moon each lunar year. [, so] Korean children can differ in age by as much as two years from their American counterparts. All Koreans born in the same year are effectively the same age.	Based on the passage about Korean ages, it is most reasonable to conclude …	During which phase of the moon do Koreans celebrate birthdays?	
			A difference in how age is calculated between Korea and the United States means that two people born in the same year can be up to two years apart in age.	**waxing**	waning

			Koreans are considered to be one year old at birth in order to ensure that everyone born in the same year has the same age.		
35	Animal behaviorists were interested in studying bottlenose dolphins in the wild. [The reason] The dolphins noticed and approached diving teams of scientists with curiosity. [is - because] The scientists spent months in the Indian Ocean tracking the dolphins. They now operate interactive dolphin tours out of the harbor for enthusiastic tourists.	Animal behaviorists were interested in studying bottlenose dolphins in the wild. [Because] The scientists spent months in the Indian Ocean tracking the dolphins. [, so] The dolphins noticed and approached diving teams of scientists with curiosity. They now operate interactive dolphin tours out of the harbor for enthusiastic tourists.	Based on the passage about dolphins, it is most reasonable to conclude …	In which ocean are scientists working with dolphins in the wild?	
			The dolphins became curious about the scientists because they were constantly in the water tracking them.	**Indian**	Caribbean
			The tourism company started tracking the habits of a local pod of dolphins in order to optimize interactive dolphin tours out of the harbor.		
36	Gilbert's syndrome prevents the body from properly processing bilirubin. [The reason] The symptoms are more pronounced among populations of adult women with the immunodeficiency	Gilbert's syndrome prevents the body from properly processing bilirubin. [Because] Episodes of jaundice may be triggered by menstruation in those with the liver disorder. [, so] The symptoms are more	Based on the passage about Gilbert's syndrome, it is most reasonable to conclude …	What type of disease is Gilbert's syndrome?	

	disease diagnosis. [is - because] Episodes of jaundice may be triggered by menstruation in those with the liver disorder. Most of the side effects of the disorder are manageable with minimal medical intervention.	pronounced among populations of adult women with the immunodeficiency disease diagnosis. Most of the side effects of the disorder are manageable with minimal medical intervention.	**Because menstruation triggers symptoms of Gilbert's syndrome, the disease affects more women than men.**	**immunodeficiency**	autoimmune
			Women are more affected by Gilbert's syndrome than men because one of the symptoms is irregular menstruation.		
37	Johnny Appleseed was really a missionary and gardener named John Chapman. [The reason] Johnny Appleseed was a welcome presence in many cabins throughout the American frontier. [is - because] John Chapman distilled his apples in hickory wood vats for the production of alcoholic cider. It's no surprise that the history of his apples became memorialized in song.	Johnny Appleseed was really a missionary and gardener named John Chapman. [Because] John Chapman distilled his apples in hickory wood vats for the production of alcoholic cider. [, so] Johnny Appleseed was a welcome presence in many cabins throughout the American frontier. It's no surprise that the history of his apples became memorialized in song.	Based on the passage about Johnny Appleseed, it is most reasonable to conclude …	What type of wood was used to create the vats Johnny Appleseed used for making alcoholic cider?	
			Johnny Appleseed was welcomed by the people of the frontier villages because his apple orchards provided them with the means to make alcoholic cider.	**hickory wood**	maple wood

			When the people of the frontier welcomed him into their homes, Johnny Appleseed made gifts of alcoholic cider to them.		
38	The red-shanked douc is an endangered species of monkey. [The reason] The primates' habitat has been shrinking down in Indonesia to dangerously low levels. [is - because] Increased tourism has created a need to develop previously forested areas. British conservationists are attempting to tag and track the remaining populations living in the region.	The red-shanked douc is an endangered species of monkey. [Because] Increased tourism has created a need to develop previously forested areas. [, so] The primates' habitat has been shrinking down in Indonesia to dangerously low levels. British conservationists are attempting to tag and track the remaining populations living in the region.	Based on the passage about the red-shanked douc, it is most reasonable to conclude …	Where is tourism on the rise?	
			The red-shanked douc have been forced out of their habitat due to increased tourism.	**Indonesia**	Cambodia
			Tourism is increasing in some areas as people travel to see the red-shanked douc before it goes extinct.		
39	Las Vegas is a city known for the neon signs illuminating its many hotels. [The reason] Many hotels have removed their well-known neon signs to	Las Vegas is a city known for the neon signs illuminating its many hotels. [Because] The Excalibur hotel found success in the 1990s by emphasizing	Based on the passage about Las Vegas, it is most reasonable to conclude …	In what decade did the Excalibur hotel find success?	

	make a classier visual statement. [is - because] The Excalibur hotel found success in the 1990s by emphasizing fantasy over flash. The process is changing the landscape of the city.	fantasy over flash. [, so] Many hotels have removed their well-known neon signs to make a classier visual statement. The process is changing the landscape of the city.	**Hotels in Las Vegas are attempting to obtain the success of the Excalibur hotel by doing away with their neon lights in favor of more subtle architectural designs.**	**1990s**	1980s
			The Excalibur hotel is attempting to obtain the success of other Las Vegas establishments by doing away with their neon lights in favor of a more subtle architectural design.		
40	The Panama Canal provides quick access from the US East Coast to Asia. [The reason] Cargo ships are increasingly using the Suez Canal in Egypt to reach Asia. [is - because] The canal charges heavy tolls based on the ship's length for transport through its lifts. The canal recently completed an expansion to allow larger ships through the passage.	The Panama Canal provides quick access from the US East Coast to Asia. [Because] The canal charges heavy tolls based on the ship's length for transport through its lifts. [, so] Cargo ships are increasingly using the Suez Canal in Egypt to reach Asia. The canal recently completed an expansion to allow larger ships through the passage.	Based on the passage about the Panama Canal, it is most reasonable to conclude …	How does the Panama Canal determine the cost of a ship's toll?	
			Ships are choosing to reach Asia via the Suez Canal instead of the Panama Canal to avoid tolls charged by the Panama Canal.	**by measuring its length**	by measuring its mass

			The recent surge in ships using the Suez Canal instead of the Panama Canal has forced the Panama Canal to raise its tolls in order to stay in operation.		
41	Al-Khazneh is an elaborate temple with ornate murals carved from a cliff face in the ancient city of Petra. [The reason] The ruin has receded during the last ten years by over 40mm. [is - because] The stone is not roped off from the probing hands of curious tourists. The site has been designated a World Heritage Site.	Al-Khazneh is an elaborate temple with ornate murals carved from a cliff face in the ancient city of Petra. [Because] The stone is not roped off from the probing hands of curious tourists. [, so] The ruin has receded during the last ten years by over 40mm. The site has been designated a World Heritage Site.	Based on the passage about the Al-Khazneh ruin in Petra, it is most reasonable to conclude …	How many years has it taken for 40mm of cliff face to erode away at Al-Khazneh?	
			Tourists touching the ruin of Al-Khazneh in Petra has resulted in the recession of it into the cliff.	**ten**	eight
			The designation of the ruin of Al-Khazneh as a World Heritage Site has increased tourism to the site, adding to its wear and tear.		
42	Valhalla is where the Norse god Odin honors warriors who have died in battle. [The reason] The god spoils the heroes with as much food and	Valhalla is where the Norse god Odin honors warriors who have died in battle. [Because] The revered Odin will need warriors to battle against the	Based on the passage about Valhalla, it is most reasonable to conclude …	What animal will battle with Odin during Ragnarok?	

	drink as they want. [is - because] The revered Odin will need warriors to battle against the wolf Fenrir during Ragnarok. It is a battle in which all are doomed to die.	wolf Fenrir during Ragnarok. [, so] The god spoils the heroes with as much food and drink as they want. It is a battle in which all are doomed to die.	**The god Odin takes care of dead heroes to ensure he has an army during Ragnarok.**	**a wolf**	a serpent
			Norse warriors who die during the battle of Ragnarok will be honored by Odin in Valhalla.		
43	The Monkey King is a Chinese trickster known for playing pranks on the gods. [The reason] The Monkey King was assigned to protect the horses among the imperial prairies of Heaven. [is - because] The Jade Emperor wanted to reduce the free time the monkey had for causing mayhem. The Monkey King viewed it as menial labor and revolted.	The Monkey King is a Chinese trickster known for playing pranks on the gods. [Because] The Jade Emperor wanted to reduce the free time the monkey had for causing mayhem. [, so] The Monkey King was assigned to protect the horses among the imperial prairies of Heaven. The Monkey King viewed it as menial labor and revolted.	Based on the passage about the Monkey King, it is most reasonable to conclude …	What was the Monkey King assigned to watch over in order to protect the animals?	
			The Jade Emperor hoped that giving the Monkey King a job would keep him so busy that he wouldn't have time to cause problems.	**the prairies**	the plains
			The Jade Emperor wanted the Monkey King to be more responsible because he needed the monkey to fulfill a job that required responsibility.		

44	Timbuktu is a city located in the country of Mali in North Africa. [The reason] Early traders used the city as a hub for the exchange of exotic goods. [is - because] The ancient city was built directly to the south of the Niger River. Rumors about the city spread along the river and enshrouded it in mysticism.	Timbuktu is a city located in the country of Mali in North Africa. [Because] The ancient city was built directly to the south of the Niger River. [, so] Early traders used the city as a hub for the exchange of exotic goods. Rumors about the city spread along the river and enshrouded it in mysticism.	Based on the passage about Timbuktu, it is most reasonable to conclude …	What is the directional relationship of the Niger River to Timbuktu?	
			Timbuktu became a popular city because its proximity to the Niger River made it a port of trade.	**south**	West
			Timbuktu was built near the Niger River in order to capitalize on the trade happening on the river.		
45	Big Foot-like creatures are said to have lived alongside American Indians near Omaha, Nebraska. [The reason] The creatures were blamed for stealing fish from lakes in the area. [is - because] Fishing production diminished in the summer months among the villages. Reverend Elkanah recorded these stories while he lived among the people.	Big Foot-like creatures are said to have lived alongside American Indians near Omaha, Nebraska. [Because] Fishing production diminished in the summer months among the villages. [, so] The creatures were blamed for stealing fish from lakes in the area. Reverend Elkanah recorded these stories while he lived among the people.	Based on the passage about Big Foot, it is most reasonable to conclude …	What type of waterway were the American Indians who started the tales of Big Foot fishing in?	
			Because fishing production declined, the American Indians in the area used the legend of Big Foot to explain the phenomenon.	**a lake**	a river

			Reverend Elkanah made up the story of Big Foot after he glimpsed a large beast scooping fish out of a nearby waterway.		
46	Marine biologists are studying the migration paths of the giant squid. [The reason] The scientists are tracking the squid's main predator, the sperm whale, near Canada's east coast. [is - because] The giant squid is a reclusive deep-sea dwelling animal inhabiting mostly Arctic waters. The squid can be shot with a tracker to determine the range of their territory.	Marine biologists are studying the migration paths of the giant squid. [Because] The giant squid is a reclusive deep-sea dwelling animal inhabiting mostly Arctic waters. [, so] The scientists are tracking the squid's main predator, the sperm whale, near Canada's east coast. The squid can be shot with a tracker to determine the range of their territory.	Based on the passage about giant squid, it is most reasonable to conclude …	Where do scientists go to track sperm whales?	
			Because squid are reclusive, scientists have to find them by looking for their main predator, the sperm whale.	**Canada**	Greenland
			Because giant squid are hunted by sperm whales, the squid dive deep to avoid them, making them particularly difficult for scientists to study.		
47	Blackbeard was a pirate with several ships who styled himself commodore. [The reason] An order was issued for governors to pardon pirates	Blackbeard was a pirate with several ships who styled himself commodore. [Because] The British crown had difficulty stopping pirating in	Based on the passage about piracy, it is most reasonable to conclude …	Who issued the pardons to pirates like Blackbeard?	

	for only their past crimes. [is - because] The British crown had difficulty stopping pirating in the vast Atlantic Ocean. Blackbeard took the pardon and settled down to a quiet life.	the vast Atlantic Ocean. [, so] An order was issued for governors to pardon pirates for only their past crimes. Blackbeard took the pardon and settled down to a quiet life.	**Because they could not catch the pirates, the British crown issued pardons to them in the hopes that the pirates would settle down.**	**governors**	magistrates
			The British crown had difficulty stopping pirating after a pardon was issued excusing piracy done in the service of the crown.		
48	Norway is officially ranked as the most developed democracy in the world. [The reason] The government can afford to provide its people with universal health care. [is - because] The country declared sovereign rights in the 1970s over oil drilling off their coast. The country is one of three in the world with a surplus economy.	Norway is officially ranked as the most developed democracy in the world. [Because] The country declared sovereign rights in the 1970s over oil drilling off their coast. [, so] The government can afford to provide its people with universal health care. The country is one of three in the world with a surplus economy.	Based on the passage about Norway, it is most reasonable to conclude …	In what decade was coastal oil drilling nationalized by Norway?	
			Norway can provide health care to its people because of the money made from oil production off its coast.	**1970s**	1960s
			Norway needed to nationalize oil production off its coast in order to pay for their universal health care reforms.		

49	Waterflooding is the process of injecting water into an oil well to stimulate production. [The reason] The water is added to force the oil towards the surface. [is - because] Oil reservoirs only pump a small percentage through their chambers on their own. Waterflooding is one of many ways to extract oil from the Earth.	Waterflooding is the process of injecting water into an oil well to stimulate production. [Because] Oil reservoirs only pump a small percentage through their chambers on their own. [, so] The water is added to force the oil towards the surface. Waterflooding is one of many ways to extract oil from the Earth.	Based on the passage about waterflooding, it is most reasonable to conclude …	What is the oil pumped through during waterflooding?	
			Waterflooding is needed because without it only a small amount of oil would be obtained.	**chambers**	valves
			Waterflooding alone only produces a small amount of oil, so other methods must be used in tandem.		
50	Fibrolamellar hepatocellular carcinoma is a rare form of cancer. [The reason] The cancer is often advanced in the kidney by the time a doctor is able to make a diagnosis. [is - because] The tumor remains asymptomatic at sizes large enough to feel from outside the body. Diagnosis is normally made by imaging and biopsy.	Fibrolamellar hepatocellular carcinoma is a rare form of cancer. [Because] The tumor remains asymptomatic at sizes large enough to feel from outside the body. [, so] The cancer is often advanced in the kidney by the time a doctor is able to make a diagnosis. Diagnosis is normally made by imaging and biopsy.	Based on the passage about Fibrolamellar hepatocellular carcinoma, it is most reasonable to conclude …	Where do tumors form during Fibrolamellar hepatocellular carcinoma?	
			Because the tumor does not produce many noticeable side effects, Fibrolamellar hepatocellular carcinoma is often advanced by the time a doctor makes a diagnosis.	**kidney**	liver

			Because the cancer is often advanced by the time a doctor makes a diagnosis, the likelihood of dying from Fibrolamellar hepatocellular carcinoma is high.		
51	The kakapo is a species of ground-dwelling parrot native to New Zealand. [The reason] The kakapo numbers have now dwindled down to critically low levels. [is - because] Domestic cats were introduced to the island in the 17th century by Europeans. The birds are asocial and hostile towards other members of their own species even during mating season.	The kakapo is a species of ground-dwelling parrot native to New Zealand. [Because] Domestic cats were introduced to the island in the 17th century by Europeans. [, so] The kakapo numbers have now dwindled down to critically low levels. The birds are asocial and hostile towards other members of their own species even during mating season.	Based on the passage about the kakapo, ground-dwelling parrot of New Zealand, it is most reasonable to conclude …	When were cats introduced to New Zealand?	
			Domestic cats in New Zealand are responsible for the endangerment of the kakapo, a ground-dwelling parrot.	**17th century**	16th century
			The kakapo is critically endangered because its asocial nature makes successful breeding difficult to achieve.		

52	One of Joan Didion's earliest writing assignments in the 1960s concerned drug use among young people. [The reason] Joan Didion used a novel, narrative-based style to help the public understand the epidemic. [is - because] Fact-based reporting could not relay the dynamic nature of ecstasy culture as told by its users. It was the piece that made Didion famous.	One of Joan Didion's earliest writing assignments in the 1960s concerned drug use among young people. [Because] Fact-based reporting could not relay the dynamic nature of ecstasy culture as told by its users. [, so] Joan Didion used a novel, narrative-based style to help the public understand the epidemic. It was the piece that made Didion famous.	Based on the passage about Joan Didion, it is most reasonable to conclude …	What drug were the young people using in Joan Didion's early writing piece?	
			The nature of the drug users' stories led Joan Didion to write a narrative news story rather than reporting the facts.	**ecstasy**	acid
			Joan Didion's reputation for having a narrative style made drug users more apt to share the stories of their lives with her.		
53	The Inca empire was a massive empire spanning from Ecuador to Chile that formed in 1438. [The reason] The Inca were easily defeated in the mountains without the need for much combat. [is - because] The smallpox virus killed millions of the Incans ahead of the Spanish arrival in Peru.	The Inca empire was a massive empire spanning from Ecuador to Chile that formed in 1438. [Because] The smallpox virus killed millions of the Incans ahead of the Spanish arrival in Peru. [, so] The Inca were easily defeated in the mountains without the need for much combat. The great empire lasted only 100 years.	Based on the passage about the Incas, it is most reasonable to conclude …	Where were the Inca defeated by the Spanish?	
			The spread of smallpox among the Inca made it easy for the Spanish to defeat them.	**mountains**	jungle

	The great empire lasted only 100 years.		Combat with the Spanish exposed the Inca to smallpox, hastening their defeat.		
54	Treehoppers are forest dwelling insects that live on every continent except Antarctica. [The reason] Large geckos let treehoppers rest on their chests between periods of feeding. [is - because] The insects have the ability to turn sap from plants into honeydew. There has not been much systematic investigation into the species.	Treehoppers are forest dwelling insects that live on every continent except Antarctica. [Because] The insects have the ability to turn sap from plants into honeydew. [, so] Large geckos let treehoppers rest on their chests between periods of feeding. There has not been much systematic investigation into the species.	Based on the passage about treehoppers, it is most reasonable to conclude …	What part of the gecko's body do treehoppers hitch a ride on?	
			Geckos let treehoppers ride on them because they enjoy eating the honeydew produced when the treehoppers extract sap from plants.	**the chest**	the tail
			Treehoppers hitch a ride to rest on geckos because it takes a great deal of energy to extract sap from plants.		
55	Aesop's fables are handed down from ancient Greek sources. [The reason] Most scholars describe Aesop as being from a desert region near Chad in North Africa. [is -	Aesop's fables are handed down from ancient Greek sources. [Because] The fables use animals from arid climates mostly unknown to the Greeks of antiquity. [, so] Most	Based on the passage about Aesop, it is most reasonable to conclude …	Where do scholars believe Aesop lived?	

	because] The fables use animals from arid climates mostly unknown to the Greeks of antiquity. His fables exist in multiple translations around the world.	scholars describe Aesop as being from a desert region near Chad in North Africa. His fables exist in multiple translations around the world.	**Aesop's use of desert animals has led scholars to believe he was from North Africa.**	**Chad**	Iran
			The popularity of Aesop's fables in Greece has led scholars to think the Greeks must have had some knowledge of animals from North Africa.		
56	Mountaintop mining involves the removal of land on top of coal seams. [The reason] Regional biodiversity has plummeted in areas miles away from the center of mining activity. [is - because] The removed rock is dumped into valleys to be swept away by now iron infused groundwater. Mountaintop mining is particularly prominent in the Appalachian Mountains.	Mountaintop mining involves the removal of land on top of coal seams. [Because] The removed rock is dumped into valleys to be swept away by now iron infused groundwater. [, so] Regional biodiversity has plummeted in areas miles away from the center of mining activity. Mountaintop mining is particularly prominent in the Appalachian Mountains.	Based on the passage about mountaintop mining, it is most reasonable to conclude …	What harmful metal is in the runoff from mountaintop mining?	
			Polluted water resulting from mountaintop mining carries toxins away from the mining sites and reduces the biodiversity of the area.	**iron**	lead

			Water sweeps debris left over by mountaintop mining into valleys until the fertile, biodiverse areas are filled.		
57	George Fox founded the Quaker religion in England. [The reason] Many Quaker converts were kept in prison for decades across the British Empire. [is - because] The Quakers openly mocked the Church of England for communion rituals emphasized by the priests. George Fox lived to see the British government release his friends from prison unharmed.	George Fox founded the Quaker religion in England. [Because] The Quakers openly mocked the Church of England for communion rituals emphasized by the priests. [, so] Many Quaker converts were kept in prison for decades across the British Empire. George Fox lived to see the British government release his friends from prison unharmed.	Based on the passage about the Quaker religion, it is most reasonable to conclude …	What type of ritual did the Quakers mock the Church of England for emphasizing?	
			Many Quakers were arrested because they were openly mocking the Church of England.	**communion**	baptism
			The Quakers spoke out against the Church of England because the English government was imprisoning them for their religious beliefs.		
58	Angelsharks are bottom-dwellers with flat bodies similar to rays. [The reason] Sea aquariums keep petting tanks stocked with the tan	Angelsharks are bottom-dwellers with flat bodies similar to rays. [Because] The angelshark has a docile demeanor and low reactivity in	Based on the passage about angelsharks, it is most reasonable to conclude …	What color are angelsharks?	

	shark for children to touch. [is - because] The angelshark has a docile demeanor and low reactivity in comparison to other shark species. In the wild, angelsharks are most commonly found in warm waters.	comparison to other shark species. [, so] Sea aquariums keep petting tanks stocked with the tan shark for children to touch. In the wild, angelsharks are most commonly found in warm waters.	**The naturally docile demeanor of the angelshark makes it safe for children to pet with some supervision.**	**tan**	grey
			Wild angelsharks should not be touched, but if an angelshark is raised by humans, it can be safely placed in an aquarium where children are able to reach in and pet it.		
59	The main environmental impact from Greek yogurt production is the creation of acid whey as a by-product. [The reason] Yogurt companies are looking to chemists for ways to reuse it. [is - because] The environment cannot absorb large doses of the whey without poisoning the ecosystem. Greek yogurt produces up to four times more whey than conventional yogurt.	The main environmental impact from Greek yogurt production is the creation of acid whey as a by-product. [Because] The environment cannot absorb large doses of the whey without poisoning the ecosystem. [, so] Yogurt companies are looking to chemists for ways to reuse it. Greek yogurt produces up to four times more whey than conventional yogurt.	Based on the passage about acid whey, it is most reasonable to conclude …	Who are Greek yogurt companies looking to for help with their acid whey problem?	
			The dangers of disposing of acid whey has led yogurt companies to invest in innovations that could reuse the waste.	**chemists**	ecologists
			The desire to make a profit by experimenting with new uses for acid whey has increased the carbon footprint of yogurt companies.		

60	There is speculation that astronaut Jerry Ross holds the record for most spacewalks. [The reason] Two Russian astronauts are currently ranked as having completed more official spacewalks than him. [is - because] Jerry Ross may have conducted several covert walks in medium Earth orbit to repair spy satellites. NASA will not confirm or deny his additional walks.	There is speculation that astronaut Jerry Ross holds the record for most spacewalks. [Because] Jerry Ross may have conducted several covert walks in medium Earth orbit to repair spy satellites. [, so] Two Russian astronauts are currently ranked as having completed more official spacewalks than him. NASA will not confirm or deny his additional walks.	Based on the passage about spacewalks, it is most reasonable to conclude …	In what orbit did Jerry Ross complete his unofficial spacewalks?	
			Astronaut Jerry Ross would likely hold the record for most number of spacewalks if spacewalks he completed during unrecorded, secret missions were counted.	**medium**	lower
			Astronaut Jerry Ross recently took on several missions to repair satellites in space in order to bring the record for most number of spacewalks back to the United States.		

Appendix Table 7 Complete list of filler trials

	Filler Trials
1	Most of Star Trek's science is based on the energy-matter conversion hypothesis. When in deep space, the ship's energy shield protects it from a hull breach. If there is a breach, the same energy can be bounded into matter to repair the hull. Although its application is fictional, the principle is rooted in science.
2	The Donskoy hairless cat was bred in the late 20th century in Russia. The cat is unrelated to another hairless breed of cat, the Sphynx. They come by their hairlessness through separate genetic mutations. Despite their lack of hair, the cats require frequent grooming and have excessively oily grey skin.
3	It is believed that animal domestication began with sheep and dogs around 16000 years ago. One way to confirm the origins of domestication is through cave paintings. For example, a painting from the 9th century BC in Iran depicts a man riding a camel. Camel domestication must reach back at least that far.
4	Almost half of the nation tuned in to hear The Beatles sing on the Ed Sullivan show. The show made the audience wait until the end before they let them perform in order to ensure the audience would watch all the way through. It's still the most watched entertainment ever aired on television.
5	The Parker Probe is the first space probe to be named after a living person. NASA launched the probe with a mission to touch the sun in as little as 12 weeks. The probe also has the distinction of being the fastest man-made object ever. It has already finished its orbit of Venus.
6	The scale of E-flat major is typically used to write music with bold sounds, as is used in heroic movies. It is unique in that it has three flats. Brass instruments

are usually used to produce the bombastic sounds. But, when paired with wind instruments, the scale produces a softer sound.

7 In 2005, the food pyramid was updated following recognition that its allowance of food was unhealthy. For example, 8 oz of beef a day was permitted under the pyramid and has been directly linked to heart disease. The importance of fats was also understated. Unsaturated fats were unduly restricted despite offering benefits to health.

8 The World Series began when the newly formed American League challenged the National League to a game. The American League's Boston Red Sox won the game against the Pittsburgh Pirates. Two years later, the Pirates renewed the challenge and restored the honor of the National League. The series has been played every year since.

9 In exercise science, the best type of workout is hotly disputed. While some experts promote cardio as a way to boost metabolism for the day to come, others point to lifting weights in the evening as a way to leverage protein synthesis. The correct answer is really based on the person's individual goals.

10 Prime Minister Winston Churchill delivered a famous speech to the House of Commons in 1940. Churchill warned that German invasion of Britain was all too possible, but that if they found allies in the New World, they could prevail together. It was an indirect plea to President Roosevelt to join the war.

11 Pluto doesn't have enough mass to clear its orbit and become the dominant body in the vast Kuiper belt. Clearing its orbit is one of the defining traits of a planet. Without that, Pluto can only be considered a dwarf planet. The reclassification rocked the world's view of the solar system.

12 Aaron Burr and Alexander Hamilton were frequent political opponents. After Hamilton attacked Burr's character during a presidential campaign, Burr

challenged him to a duel with repeating caplock pistols. Burr won the duel, killing Hamilton to the outrage of the nation. He then lost the presidential election.

13 The most labor-intensive activity on farms is the harvest. It's no surprise then that the greatest number of farming machinery is dedicated to making this process more efficient. For example, specialized equipment is used to remove seeds from the crops as they are transported down a conveyor belt.

14 Ironically, the first video ever to air on MTV was Video Killed the Radio Star. The song had actually been written in the decade prior to the 1980s launch of MTV. Its lyrics seemed prophetic, but in later decades, MTV played less and less music whereas music still dominates the radio.

15 Most people think of dyslexia as seeing words or letters that are reversed, but that phenomenon only occurs in a small number of dyslexic patients. Instead, people with dyslexia often see the words move while reading and report migraines, nausea, and dizziness. Reading is literally painful for them.

16 The ancient pharaohs of Egypt built more pyramids than just the three famous pyramids of Giza, but not all have survived. The Black Pyramid, built by King Amenemhat III, only survives in partial form. When originally built, the pyramid had a polished granite capstone. The pyramid was originally one of eleven.

17 Theodore Roosevelt is still the youngest person to have ever served as President. Roosevelt was sickly as a child, but rather than resting in bed, he pushed himself to roam the outdoors to recover. As president, he pleased many environmentalists when he set aside land for preservation by creating the national parks system.

18 Chinchillas live in herds in the high altitudes of the Andes. The rodents have the densest fur of all mammals with sixty hairs sprouting from a single follicle, but

they are so small that it takes many of the animals to make one shawl. Many Peruvians also keep them as pets.

19 The pepper-box revolver is a multiple-barrel firearm. One powder charge can accidentally ignite all the other charges in the weapon simultaneously. This can have a bonus effect of launching many bullets simultaneously, but if the person firing isn't ready for it, it can cause unexpected kickback, knocking some off their feet.

20 The Emancipation Proclamation did not free all slaves. Lincoln's proclamation freed slaves living in states in open rebellion against the United States. Delaware, a state that did not secede, still could and did hold slaves. Slaves in Delaware were freed until after the Civil War ended in 1865 when the 13th Amendment became law.

21 Good hygiene has often been hailed as one of the reasons for the superior health of modern society. However, too much cleanliness is paradoxically blamed for conditions such as polio and the rise of autoimmune disorders. It seems that some exposure to germs is good for the body. Moderation seems to be the key.

22 Many of today's most widely known fairy tales were written by Hans Christian Andersen. His tales reflect Christian ideology, but many of his characters were also based on folklore he heard while growing up in Denmark. He included subtle pagan rites from this lore within an otherwise Christian framework.

23 Mexico's government legalized the ownership of slaves in the early 19th century. The hope was that it would persuade affluent Americans to immigrate from the West into Mexico. However, only a few years later, the government changed their mind, turning their state into more of a democracy and banning slavery for good.

24 Jersey is a small island nation off the coast of England. As a reward for harboring him during the English Civil War, King Charles I gifted the people of Jersey a swath of land in the new world. They fittingly named this land New Jersey. However, the land was ultimately settled by the Dutch.

25 Asian gypsy moths are invading the United States and wreaking billions of dollars of havoc. They feed more voraciously than other moth species and secrete harmful substances from their glands as they feed. Cargo ships inbound from Asia, believed to be full of eggs, are being asked to spray their ships with biopesticides.

26 Early on, human embryos develop gill slits in the neck. These slits will eventually close, leaving just one open for development of the ear. Later, the embryo will develop a tail which recedes to form the tissue of the coccyx. It's unclear to biologists why the human embryo develops and then discards such features.

27 The unicorn has captured the fancy of many cultures. Archeologists have found depictions of single-horned animals on seals from vessels in Persia. Despite early speculation that they may depict unicorns, it is believed that the single horn is a result of showing the image in profile.

28 The Great Famine was a period of starvation that happened in Ireland during the mid 19th century. However, the Irish didn't starve due to any environmental disaster. They had plenty of potatoes, but the British forced the Irish to export them to compensate for disease among crops throughout the rest of Europe.

29 Alan Shepherd, the first man to be launched into space by NASA, decided to drink a bunch of coffee before he took off, but NASA didn't have a way for him to relieve himself once he was strapped to the rocket. Shepherd became the first man to pee his pants in space.

30 The Grave Creek Mound in West Virginia is a remnant of an ancient civilization. Weapons made out of obsidian were found at the site, but obsidian only occurs in volcano-rich regions. A vast trade network must have existed in ancient North America for such rock to appear so far from a volcano.

31 Social security funding is a growing concern in the United States. Rumors of funding being depleted over the next several decades have been spreading in the news. However, politicians claim that they will continue to ensure funding for social security. The truth about its longevity is difficult to ascertain.

32 Prohibition demonstrated that laws have little power over the people. During Prohibition, otherwise law-abiding citizens overwhelmed police with their willingness to disregard the law. Police also felt little motivation to arrest citizens for indulging in an activity of which they themselves partook. In the end, people, not Congress, decide what laws to keep.

33 C++ is a dangerous but powerful computing language. It allows for low-level manipulation of memory that can cause deep-seated and difficult to fix bugs in final programs. But that very same ability to manipulate memory allows programmers to create well-optimized and concise programs that virtually run the world.

34 Louis-Auguste was the last real monarch of France. While hated for the way his deregulation of the grain market affected commerce, he wasn't all bad. He tried to abolish serfdom, increase tolerance toward non-Catholics, and rescind laws requiring baptism. He also supported the United States during the Revolutionary War.

35 The Midwest has a surprising amount of environmental diversity. For example, Lake Michigan is big enough that you won't know you're not surfing in the Atlantic as you ride the waves. And the dunes off of Lake Michigan might even make you think you're visiting the desert. It's a popular vacation spot for locals.

36 The Theremin is an early electronic musical instrument controlled without the need for physical contact. The contactless mechanism made control of the pitch difficult for even experienced players, but its novel sound made it worth the extra effort. Despite some waning in popularity, the Theremin still has a niche following today.

37 The Song dynasty controlled much of what is now modern day China during the 11th century. This was a period of innovation in China. Gunpowder, compasses and bank notes were all invented by the Chinese of this era. The use of paper money makes this government the first capitalist regime in history.

38 Art is loosely defined as the creation or destruction of something. Some artists believe that everything an artist does is art. This can include mundane tasks such as cleaning or mailing a letter. While widely acknowledged within the art world, this is not a take on art that the general public usually accepts.

39 Stress is a culprit behind many bodily ailments. Long-term stress can lead to a breakdown among the neural networks of the hypothalamus. Additionally, chronic stress has been linked to ulcers among those with poor stress-release outlets. Exercise can be particularly important among those with high-stress jobs.

40 Perhaps unsurprisingly, Europeans were one of the last to adopt guns as weapons for warfare. After the invention of gunpowder by the Chinese, it travelled East through Arabia, where, in the 16th century, its usage radically changed warfare. The major players in the Middle East became known as the Gunpowder Empires.

41 The emergence of prison unions is a relatively recent phenomenon, and with unions come strikes. There are split opinions among the general public about allowing prisoners to form unions, but prison strikes channel suppressed rage into

constructive discourse between the inmates and the wardens. This reduces the risk of harm for all involved.

42 The bubonic plague has killed over 50 million people across Asia and Europe. The Mongolian steppes are still inhabited by a rodent host that carries the plague virus, but people who acquire the bubonic plague today often recover from the illness. The last deadly outbreak was in China in the mid-19th century.

43 Most of Earth has been thoroughly explored and cartographers have precise maps of seemingly every rock and hill. However, sometimes the maps are just plain wrong. For example, scientists were recently visiting Sandy Island in the Coral Sea only to discover that the island does not exist and never did.

44 If you look at a microwave closely, you'll see small holes in a metal sheet beyond the glass. These holes allow people to visualize the contents. They must be small enough that they block the micro waves that are heating the food from escaping. Glass does nothing to protect people from damaging waves.

45 Archaeology in Israel is complicated by its numerous layers of history. Archaeologists want to uncover the bottom layers to investigate the earliest evidence of civilization, but in doing so they would have to destroy all the layers between the top and the bottom, and millennia of history would be lost forever.

46 Only one species of penguin lives above the equator, and no, its home is not in Greenland or other cold countries. This penguin makes its home among the Galapagos Islands. It has not evolved into a warm-weather bird, either. Rather, a special current brings cold waters to the warm islands.

47 Atmospheric pressure is one thousand times greater at the deepest levels of the ocean. With modern technology, scientists for the first time can journey

lower than ever before to understand deep sea life. They have found many new species, but they have not figured out how to keep them alive at the surface.

48 Names of wine reflect more than the taste or grape used to make them. Wine names reflect their region of origin. For example, champagne legally refers only to wine made in Champagne, France, though imitation sparkling wines are made worldwide. Another such wine is port, which refers only to wine made in Portugal.

49 Technology from WWII opened new doors for the exploration of Earth. A German missile was repurposed to launch high above Nevada with a camera in tow. The camera parachuted back to Earth in a metal container unharmed and the first images from space were available for study.

50 President Eisenhower was president during the first missions to space. Under the guidelines laid out by him, Neil Armstrong could not be an astronaut. Eisenhower saw the space missions as military endeavors and Armstrong's tour of duty was over. Later, under Kennedy, NASA relaxed the guidelines.

51 In Mexico, presidential candidates may request a police escort for their safety throughout the campaign. However, when one recent candidate declined the option, the government covertly followed him anyway. In some people's minds, this confirmed suspicions that the escort service was just a covert way to spy on opponents.

52 A few people today grow much of their food at home, but they are in a vast minority. That might change in the future with the introduction of smart grow systems which use technology, such as precision grow lamps, to make growing food easier. Locally grown may mean home grown soon.

53 The Tower of Babel has great importance to Mormons. The story says that as punishment for trying to build a structure to reach the heavens, language was

taken from the people. But Jared, who was a holy man, was spared and told to take his family to New World.

54 The Code of Hammurabi is perhaps the first record of law ever to be put to print. More than just laying down laws regarding taxes and justice, the code identifies specific gods to worship, such as Ninazu as the patron of healing. Ninazu is often depicted with a serpent and staff symbol.

55 In 1869, the 15th amendment to the constitution, giving African American males the right to vote, came before the states for ratification. In some states, even ones who fought with the Union during the civil war, many Democrats resigned their office rather than even consider the amendment for ratification.

56 The Marshall Plan was designed to lift Europe out of the economic carnage of WWII. However, the Soviet Union, suspicious of an alternative agenda, forbid Soviet-controlled states from accepting the offer to rebuild their countries. The tension created from this ultimately led to the building of the Berlin Wall.

57 Brown bananas are often tossed in the bin or passed over at the market. However, recently researchers have discovered that spotted bananas contain a compound called Tumor Necrosis Factor that can destroy cancerous tumors. It is possible that a brown banana a day could keep the cancer away.

58 An opera and a musical are both defined as a story that is set to music. However, musicals incorporate dancing and acting that involves speech-like singing and the use of a microphone. Opera, on the other hand, involves a fuller sound that is always supported instead of belted.

59 Parental depression often impacts the eldest children disproportionately. For example, at eight, Alison Bechdel, the famous writer, reports feeling responsible for providing care for her younger siblings and her depressed mother.

Not surprisingly, this sort of role often falls on eldest daughters more so than on eldest sons.

60 Black holes are regions of spacetime that have such strong gravitational effects that nothing can escape from inside. The theory is that when atoms are compact enough, they can deform spacetime to form a black hole. Spacetime here refers to the inclusion of time as a fourth dimension of space.

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